Inquiry on Federal Water Policy

Enquête sur la politique fédérale relative aux eaux

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THE FEDERAL ROLE IN WATER MANAGEMENT

by

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Canada

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THE INQUIRY ON FEDERAL WATER POLICY

The Inquiry on Federal Water Policy was appointed by the federal Minister of the Environment in January of 1984 under the authority of the Canada Water Act. The members were Peter H. Pearse, chairman; Françoise Bertrand, member; and James W. MacLaren, member. The Inquiry was required by its terms of reference to review matters of water policy and management within federal jurisdiction and to make recommendations.

This document is one of a series of research papers commissioned by the Inquiry to advance its investigation. The views and conclusions expressed in the research papers are those of the authors. Copies of research papers and information on the series may be obtained by writing to the Enquiry Centre, Environment Canada, Ottawa, Ontario K1A 0H3.

Frank Quinn
Director of Research

Abstract

This review assesses major federal legislation policies and programs related to water resource management in Canada, exclusive of its provincial-type role in Yukon and the Northwest Territories.

The constitutional setting is described, including its uncertainties highlighting the need for federal-provincial cooperation. Ten federal laws relating to water are examined and recommendations presented to improve the Canada Water Act, Environmental Contaminants Act and the Fisheries Act.

Major federal programs assessed include those related to water quantity and quality monitoring, planning, regulation, flood damage reduction, regional water development, Great Lakes water quality management, municipal facilities funding, toxic chemicals and airborne pollutants. Recommendations are presented to strengthen programs as appropriate.

Résumé

Ce rapport évalue les principaux programmes, politiques et législations fédéraux reliés à la gestion des ressources hydriques au Canada. Il n'aborde cependant pas le rôle du gouvernement fédéral dans les Territoires du Nord-Ouest et du Yukon.

Le contexte constitutionnel y est décrit et les incertitudes en résultant sont soulignées ce qui met en lumière la nécessité d'une collaboration fédérale-provinciale. Les lois fédérales se rapportant à l'eau sont examinées et des recommandations sont faites afin d'améliorer la Loi sur les ressources en eau du Canada, la Loi sur les contaminants de l'environnement et la Loi sur les pêcheries.

Les principaux programmes fédéraux évalués comprennent ceux reliés à la surveillance de la quantité et de la qualité des eaux, à la planification, à la règlementation, à la réduction des dommages causés par les innondations, au développement régional des ressources hydriques, aux grand lacs, à la gestion de la qualité des eaux, aux financement des équipements municipaux, aux substances toxiques et aux polluants aéroportés. Des recommandations sont présentées afin de renforcer ces programmes lorsque nécessaire.

CONTENTS

1. INTRODUCTION

1. INTRODUCTION

This review was undertaken for the Inquiry on Federal Water Policy. It attempts to outline and assess the federal government's roles in water administration as defined by its legislation, policies and programs. The study was based on interviews with senior staff of federal agencies directly involved with water management and documentation provided by them.

To set the stage, it seemed essential to describe the constitutional setting and the uncertainties it creates respecting federal and provincial jurisdictions. Within this setting, the major federal water legislation is summarized and recommendations are made to overcome deficiencies. The review then examines major federal water programs.

The report is restricted to a discussion of the federal government's national roles, excluding its provincial-type responsibilities exercised in Yukon and the Northwest Territories. The initial intention was to include a chapter on territorial water management, but in the end it was decided not to do so. The management of water in the North is too significant a topic to be included as a mere adjunct to a discussion of federal water policies. Water management policies and programs of the Department of Indian Affairs and Northern Development stand on their own, just as do those of a province, and should not be confused with "federal" water policies and programs. They are provincial-type rather than national. Through the courtesy of the Department of Indian Affairs and Northern Development, a separate report which I completed in 1984, "Water Policy North of 60°", is submitted to the Inquiry for its consideration.

Concentration on federal programs dealing with the more significant issues of the day turned out to be inescapable. As a result, a number of programs of importance are not discussed. The operation of the St. Lawrence Seaway, numerous control boards, investigative-engineering boards and advisory committees reporting to the International Joint Commission are examples of important programs that are not dealt with.

Since the Inquiry commissioned a separate study concentrating on federal water research programs, they are only considered here in relation to several water management issues rather than as programs in their own right.

Meaningful and comparable statistics on financial and personnel resources allocated to various programs were not usually available. Accounting systems differ from department to department and within departments they change on a too-frequent basis. Where obtainable, figures are included in the discussion of individual topics. Some general statistics are included in the Appendices.

The recommendations contained herein have been developed in recognition of the budgetary restraint situation confronted by all levels of government. No new major initiatives are proposed. Instead, the emphasis has been placed on fine-tuning, improving the coordination of programs, providing for stronger centres of authority and responsibility, and maintaining a state of readiness to respond to new issues as they arise.

2. CONSTITUTIONAL FRAMEWORK FOR WATER RESOURCE MANAGEMENT

2. CONSTITUTIONAL FRAMEWORK FOR WATER RESOURCE MANAGEMENT[1]

2.1 Introduction

Much has been written by legal scholars about the powers of the provincial and federal governments respecting water resources. Rather than attempt to present an exhaustive review, the following discussion outlines the major responsibilities of the governments in Canada, areas of uncertainty, and options available for resolving disputes and effecting cooperation.

2.2 Provincial Powers

Provincial powers derive from Sections 109 and 92 of the Constitution Acts of 1867 to 1982. Section 109 bestows the ownership of public lands, mines and minerals to the provinces. This has been interpreted to include the proprietary rights to rivers and other watercourses (Zimmerman, 1969), excepting those waters occurring on federal lands within the provinces. With proprietary rights to water and fish therein, the provinces can regulate the rights to use them within their respective territories, except for those rights that by common law are public rights, namely the right to navigate in virtually all waters and the right to fish in tidal waters.

Section 92 provides legislative powers to the provinces including: the management and sale of public lands; property and civil rights; local works and undertakings; and, generally all matters of a merely local or private nature in the province. Section 92A, added in 1982, provides the provinces with exclusive powers in relation to the development, conservation and management of sites and facilities for hydroelectric power generation.

Basically, as the owners of the rights to use water and with the power to regulate property, local works and undertakings, and matters of a local nature, the provinces are the water managers. They can

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1 This discussion excludes consideration of federal lands, including Yukon and the NWT where the federal government has full jurisdiction over water.

determine its apportionment and regulate its quality to meet provincial, economic and social objectives. As all private business managers find, however, there are a number of constraints that have been placed on a province's water business. These constraints are found among the constitutional powers of the federal government.

2.3 Federal Powers on Internal Provincial Waters

The two principal federal powers are those respecting two specific uses of watercourses, fisheries and navigation. In a sense, those responsible for fisheries and navigation are clients of the water managers. In another, and more realistic sense, fisheries is an industry with fish habitat as the resource base and fish the product. When looked at in this way, the federal government is the manager of a resource, fish habitat, that occurs within another resource, watercourses, that it does not own. Whether clients or managers, the requirements of the federal fisheries and navigation authorities must be met, even if they constrain or prevent a province from meeting the demands of customers for other water uses.

2.3.1 Fisheries

While the provinces possess the proprietary rights to their fish as they do for water, it is the federal government that controls the protection and conservation of fisheries under Section 91(12). These powers directly constrain other uses of watercourses. The federal government, for example, can regulate local works and undertakings to ensure the maintenance of fish passage and to protect spawning, rearing and other habitat areas from physical disturbance and pollution detrimental to fish.

2.3.2 Navigation

Section 91(10) gives the federal government exclusive legislative authority over navigation and shipping. It can control the design

and construction of any structure that might interfere with navigation, regulate the deposit of rubble and other material that could interfere with navigation, and define waste disposal restrictions for ships and shipping facilities.

2.4 Indirect Powers

Besides these federal powers directly related to water, there are several indirect powers that could influence a province's authority over its internal waters. The statistics power (S. 91(6)), for example, is used as a basis for gathering various data on water supply, quality and use. Involvement in irrigation programs and the control of pollution affecting agriculture could be justified on the federal agriculture power. The criminal law powers of S. 91(27) might be employed to prohibit, or possibly regulate, pollution, although as Gibson (1973) points out, the courts have restricted federal jurisdiction under S. 91(27) to those activities "essentially criminal" in nature. It is unclear whether the control of pollution not seriously dangerous to public health, or the regulation rather than the prohibition of dangerous pollutants, could be dealt with under the criminal law power.

Although not defined in the Constitution Act, the federal government does employ its "spending power" to influence the exercise of provincial water management. Federal grants or resources committed to federal-provincial programs, such as the current flood hazard reduction programs, often contain conditions that steer the direction of provincial policies and priorities.

2.5 Federal Powers on Interjurisdictional Waters

In addition to these direct and indirect federal powers that may constrain a province's management of its internal waters, there are other federal powers that can influence activities within a province that could have impacts beyond the province's border, in the United States or in another province.

2.5.1 Treaty Power

Under Section 132, the federal government has all the powers necessary to fulfill Canada's obligations arising from international treaties made while Canada was part of the British Empire. Two treaties are of importance here. Under the Boundary Waters Treaty (1909), the federal government can take the steps necessary to protect open and free navigation and the maintenance of natural levels and flows of boundary waters, those waters that flow along or are part of the Canada-United States border, but excluding tributaries thereto. The Treaty also commits Canada to prevent pollution of both boundary waters and waters flowing across the boundary "to the injury of health or property" in the United States. This power would extend to the Great Lakes, part of the St. Lawrence and several major watercourses crossing or part of the border such as the Okanagan, Columbia, Souris, Saint John and St. Croix.

The second treaty of significance is the Migratory Birds Convention of 1916 designed to protect migratory birds, not only from excessive hunting but from other hazards such as water pollution. Authority to regulate pollution deleterious to migratory birds would apply anywhere in Canada frequented by migratory birds, virtually everywhere.

2.6 Federal Powers on Interprovincial Waters

Provincial authorities relate to things and activities internal to a province. As Canadian waters become more intensively used and plans proceed for further developments, actual and potential impacts on downstream provinces have grown in importance. Waste disposal in one province has caused problems in another. Storage dams have resulted in ecological damage downstream. Proposals to divert waters from one basin to another, to expand irrigation programs or build

new hydroelectric installations have potential implications for downstream provinces and territories. Are there additional federal powers tailored to deal with such interprovincial issues?

The Constitution Act is silent on the specific issue, but there are federal powers that seemingly could be brought to bear to regulate activities in one province that could have injurious effects downstream in a neighbouring province or territory.

There is the declaratory power of Subsection 92(10)(c) under which the federal government may exercise jurisdiction over works within a province by declaring them to be for the general advantage of Canada or of two or more provinces. While the power is there, Percy (1984) points out that it has become a politically sensitive authority and has not been employed since 1961.

Subsection 92(10)(a) gives authority to Parliament to control works and undertakings that extend beyond the limits of a province. This power could be applied to regulate a proposed dam that would create a reservoir extending upstream into another province. It is unlikely, however, that the power could be applied to regulate the same project to prevent or minimize injurious impacts in a downstream province or territory. The opportunity to find out arose when British Columbia built the Bennett Dam on the Peace River, but the federal government did not act to influence the operation of the project or the schedule used to fill that reservoir.

Section 91 of the Constitution Act (1867), provides federal authority to legislate for the peace, order and good government of Canada on any matter not exclusively assigned to the provinces. The federal government carries out a variety of research programs under this authority such as those relating to the health effects of contaminants on drinking or recreational water. These are generally welcomed by provinces since the results of research have national applicability, save duplication of effort, and do not threaten provincial sovereignty.

But when does a problem reach the status of influencing the peace, order and good government of the nation to the extent that the federal government could exercise some regulatory powers? Gibson (1969 and 1973) took the view that the power could be used by the federal government to create multi-use river basin administrations or to settle interprovincial disputes, or to legislate the basis under which such disputes are to be settled. The applicability of the peace, order and good government power seems to depend, however, on the degree of national interest involved in a particular issue.

Chesman (1984) has outlined the situation. He points out that in a judgement respecting A.G. Ontario v. Canada Temperance Foundation (1964), (A.C. 193 at 205-206), the Privy Council spoke of a national concern to sustain the federal power. Quoting from Chesman, the judgement read in part that:

> "the true test (of the residual POGG power) must be found in the real subject matter of the legislation: if it is such that it goes beyond local or provincial concern or interest and must from its inherent nature be the concern of the Dominion as a whole ... Parliament, as a matter affecting the peace, order, and good government of Canada although it may in another aspect touch on matters specially reserved for the provincial legislature."

In a later case, however, know as the Anti-Inflation Reference (1976), 2S.C.R. 373 (S.C.C.), federal legislation was held to be valid under the peace, order and good government power because it addressed a matter of national emergency.

Chesman (1984) has outlined a logic for determining when the national concern or national emergency criterion would be most appropriate. First put forward by Lederman (1975), the argument outlines two situations for which use of the residual power would be appropriate. The first category would provide federal jurisdiction over specific

subjects that are of national interest and have emerged since 1867. Aviation and atomic energy are two areas given as examples. The second category would call for federal jurisdiction over a situation that had reached the dimensions of a national emergency, something that justifies temporary assumption of authority pending solution of an issue.

It is notable that this is the approach that seems to have been used by the drafters of the Canada Water Act (1970). Part I of the Act deals with comprehensive water management programs. It provides for unilateral federal action for interjurisdictional basins where all reasonable efforts to reach agreement with provinces have failed and where there is a significant national interest. For interprovincial basins, however, the unilateral action provision extends only to planning activities. Only for international basins, where Parliament has firm authority through the Boundary Waters Treaty, does the Act provide for unilateral federal implementation of planned projects.

Part II of the Canada Water Act provides for the establishment of water quality management agencies to plan and implement programs to restore, preserve and enhance water quality in designated areas. Part II provides for unilateral federal action when federal/provincial agreements cannot be reached but, unlike Part I, the provision extends to the actual implementation of programs. Part II, however, is only applicable in situations that have become of urgent national concern.

In 1978, the federal government published its interpretation of "significant national interest" as follows:

> "'Significant national interest' includes, but is not limited to, areas of direct federal responsibility. Examples of cases of significant national interest would include the management of boundary and international waters, interprovincial waters, waters in Indian reserves, national parks and the Territories; issues involving other federal waters, cases where federal jurisdictions, such as fisheries or navigation are major concerns; or such

> other cases as are deemed by the Ministers to be of sufficient importance to the people and economy of Canada as to require federal involvement, e.g. disruption of regional economies by major floods."[1]

It would appear then that the federal government might be inclined to formulate comprehensive water management plans for interprovincial waters should provinces not agree to joint planning.

The course the Supreme Court of Canada might adopt in dealing with interprovincial water disputes would, of course, depend on the specifics of a case presented to it. While there has been no case of unilateral federal action under the Canada Water Act, and no water disputes brought before the Court involving two provincial governments, there has been private litigation. A recent case yields insights into the constitutional frustrations the Court would have to deal with should a downstream province launch an action against its upstream neighbour or should provinces object to a unilateral federal approach under the Canada Water Act.

In 1975, the Court dealt with a case involving Interprovincial Co-operatives Ltd. v. the Queen in the Right of Manitoba. The problem concerned provincially licensed chlor-alkali plants in Saskatchewan and Ontario whose effluents contained mercury that found its way downstream into Manitoba waters and contaminated fish. Closure of a commercial fishery in Manitoba caused losses in the fishing industry. Manitoba sued Interprovincial Co-operatives Ltd. on behalf of the fishermen.

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[1] Environment Canada, 1978. A vital resource: federal policy statement on inland waters. Ottawa.

The heart of the issue was whether or not a province, in this case Manitoba, has the power to legislate respecting the quality of water entering the province. That is to say, could Manitoba's law influence pollution control requirements in Saskatchewan and Ontario? Similarly, it could have been asked whether or not Saskatchewan and Ontario have authority to license waste disposal in a way that caused injury in Manitoba. As Percy (1983) pointed out, "the crucial issue is whether the tort is legally considered to have been committed in the jurisdiction in which the act took place or in the jurisdiction where the harm was suffered".

In the course of their comments, several of the Supreme Court Justices made statements bearing on the roles of upstream provinces, downstream provinces and the federal government in the management of inter-provincial waters. These quotations are taken from the Dominion Law Reports (Vol. 33, Sd) (S.C.C.).

Laskin commented that:

> "It is plain enough to me that a Province having rights in property therein (fish) is entitled to protect those rights against injury, and similarly, to protect the interests that others may have in that property, by bringing or authorizing actions for damages ..." (p. 335)

But since a province's authority to legislate within the powers defined in S. 92 of the Constitution Act is restricted to matters within its boundaries, how can a province protect itself from pollution or reduced streamflow caused by actions taken in an upstream province?

Ritchie argued that:

> "... if there were licences making the appellant's activities in Saskatchewan and Ontario justified, this not only gave rise to the civil rights under the law of those provinces, but to a concomitant civil right to have those licences recognized in the Courts of Manitoba." (p. 349)

On the other hand, Laskin's view was that:

> "If ... they are respectively licensed to discharge contaminants to the extent that they did, that licence, local in each of the provinces, does not have an extra-territorial reach to entitle each of them with impunity to send their pollutants into the waters of another province." (p. 338)

And Pigeon said that:

> "It appears to me equally impossible to hold that Saskatchewan and Ontario can license the contaminant discharge operations so as to preclude a legal remedy by those who suffered injury in Manitoba, or to hold that Manitoba can, by prohibiting the discharge of any contaminant into waters flowing into its territory, require the shutting down of plants erected and operating in another province in compliance with the laws of that province." (p. 359)

Several of the judges took the view that interprovincial issues relating to pollution control were matters of federal rather than provincial jurisdiction. Chief Justice Laskin commented that:

> "... if any regulatory authority to have inter-provincial effect is to exist in respect of pollution of interprovincial waters it would have to be established under federal legislation." (p. 358)

Ritchie stated that:

> "Legislation in respect of water quality and of pollution, including the permitting thereof in interprovincial rivers, is clearly within the exclusive legislative authority of the Parliament of Canada under S. 91(12), whereas provincial legislation dealing exclusively with the effect of pollution including the proof thereof and

> the measure of damage resulting therefrom, has controlling effect within the territorial limits of the province by which it is enacted." (p. 346)

Pigeon stated that:

> "The basic rule is that general legislative authority in respect to all that is not within the provincial field is federal." (p. 357)

The range of comments must give both the provinces and the federal government pause for thought. In a future case, the Court might rule that a province's exclusive right to regulate use of its internal waters is limited by the riparian rights of downstream provinces. Alternatively, the Court might modify strict riparian principles and adopt rules providing for some degree of reasonable use by upstream provinces with its affects downstream being considered acceptable. Whether or not the Court would uphold federal regulatory involvement, would depend on its interpretation of the nature of the issue, be it of national concern, or national emergency; but some of the judicial comments quoted above suggest the Court may be leaning toward a federal role. The uncertainties are such that clarification at the political level is required. What options are there?

2.7 Clarifying the Federal Role

2.7.1 Federal Legislation

Any attempt by the federal government to assert power to regulate water flows or quality at interprovincial boundaries would undoubtedly be met with strong opposition by the provinces, unless an issue of national emergency were involved. The reason for provincial opposition is obvious. Federal controls at border points could have far reaching effects on a province's powers to manage its water far upstream from its border.

The nature of the Canada Water Act recognizes these potential issues and indicates a federal unwillingness to attempt to assert regulatory powers over interprovincial waters except in the unlikely event of national emergencies.

Instead of attempting to legislate itself a regulatory role, the government might adopt a more passive role. Since there could be procedural difficulties in determining which court should hear a dispute between two provinces, the federal government might act to clarify the situation. Section 19 of the Federal Court Act already provides for that court to hear interprovincial disputes, with appeal to the Supreme Court, should provinces legislate accordingly. All have done so with the exception of Nova Scotia and Québec. It is within the realms of possibility, however, that a province engaged in a dispute as defendant could legislate itself out of the arrangement in an attempt to avoid litigation. In such a situation, the federal government might be able to legislate compulsory jurisdiction of the Federal Court to overcome a dilema of national concern. Gibson (1973) believed such action would be supportable under the peace, order and good government power.

While legislating the authority of a particular court could obviate procedural problems, it would not assist that court in determining the principles on which to base its decisions. The uncertainties present today would persist, at least until several interprovincial disputes had been ruled upon. But if the federal government were to attempt to incorporate such guidelines in law, it would undoubtedly be challenged with attempting to tamper with provincial rights. In the end, the pursuit of federal legislation to deal with interprovincial water management issues does not seem to offer useful solutions.

The only option left is cooperation through federal/provincial agreements or perhaps ideally through Constitutional amendment to set the guidelines for such cooperation.

2.7.2 Interprovincial/Federal Agreements

The very nature of Canada has led to the negotiation of federal/provincial agreements to deal with a whole range of issues that have emerged over the years, varying from medicare to regional economic development and water resource management. Some of these agreements provide insights into basic principles acceptable to governments that should be useful to guide the development of future cooperative arrangements.

The most pertinent example of interjurisdictional water management arrangements in Canada are the Apportionment Agreements between Alberta and Saskatchewan, Saskatchewan and Manitoba, both covered by the Master Agreement on Apportionment involving three provinces and the federal government. The interprovincial agreements provide for the sharing of natural flows of streams flowing eastward from province to province; cooperation for effecting the most economical and beneficial use of interprovincial waters; and, the settlement of disputes by the Federal Court.

The Master Agreement gives effect to the interprovincial agreements, provides for their amendment or cancellation, and reconstituted the Prairie Provinces Water Board to administer the agreement. The Master Agreement adds the important dimension of water quality to the extent that the governments agreed to consider quality problems, refer them to the Board, and consider the Board's subsequent recommendations.

A key principle pervading these agreements is that the sovereign power of each province to manage its internal waters is maintained, constrained only by the agreed apportionment. How a province is to meet its obligations at the border is left up to it.

The first emphasis is on assuring each province its share of the resource for its internal development and use according to its own priorities.

With shares assured and development priorities protected, <u>the provinces adopted the principle of fullest cooperation on the integrated development and use of water and related resources</u>.

Complementing the continuing integrity of provincial powers is the role adopted by the federal government. <u>The federal government plays the role of convenor and honest broker</u>, providing the chairmanship of the Board and undertaking the required stream monitoring as an objective third party.

Through the agreements, the federal government gains an element of clout in that the agreements cannot be amended or cancelled except with the consent of all four governments.

The background that led to the adoption of these basic principles has been well described by Barton (1983). Basically, after some years of operation as an advisory board examining and recommending on water use proposals in each province, it became apparent that water development apportionments granted to one province could constrain some future developments in another province. A need was felt for each province to have some guarantee of supply regardless of when the real demand for use might arise. With this realization, the two upstream provinces concluded an apportionment agreement between themselves and Saskatchewan and Manitoba worked out a similar agreement. Lastly, the Master Agreement incorporated the first two and added the federal government as the fourth party. Adoption of similar principles protecting a province's or territory's basic sovereignty in water management and protecting its future supplies for development at its own pace will undoubtedly be required as a prerequisite for cooperation agreements on other interprovincial basins.

2.7.3 Constitutional Amendment

With the exception of three Atlantic Provinces, all provincial and territorial water management options are subject to influences of activities in an upstream or neighbouring province. All provinces and territories are subject to water quality problems resulting from the long-range transport of air pollutants. Perhaps the time is ripe to consider development of an accord involving all provinces, territorial and the federal government incorporating objectives and management principles to protect the interests of each and encourage cooperation among all. If such could be accomplished, a practical goal would be to incorporate it in the Constitution.

There is much experience to draw on. For example, while the particular apportionment formula selected by the prairie provinces could not be expected to be appropriate for other river systems, the Prairie Provinces Water Board has moved forward on water quality questions and has produced a set of general quality objectives that could prove useful for other interprovincial waters. In 1973, the Board agreed on a set of general water quality objectives based on a "universal user" concept and not taking account of the individual characteristics of individual streams. These objectives, currently under review for possible amendment, would have application in other basins.

In 1983, the Board produced both general and specific water quality requirements for the Alberta/Saskatchewan crossing of a specific river, the Beaver. The general requirements at least should have applicability elsewhere.

Under the aegis of the Canadian Council of Resource and Environment Ministers, the provinces and federal government are developing a set of water quality guidelines for adoption on a national basis.

There are a variety of other federal/provincial agreements on different basins relating to Canada's international obligations under the Boundary Waters Treaty. The Canada/Ontario Agreement Respecting Great Lakes Water Quality (1971 and 1982) contain a set of principles respecting water quality management. The Canada/Québec/Ontario Respecting Ottawa River Basin Regulations (1983) contain principles to guide the regulation of flow for flood protection while maintaining the interests of hydroelectric production and other uses. These are the two most recent of a number of federal/provincial agreements on aspects of interjurisdictional water management.

In the United States, the courts have settled a variety of interstate disputes, creating a body of principles on equitable apportionment along the way. The United Nations International Law Commission has made progress in enunciating principles respecting the non-navigational use of international watercourses. Perhaps it is time for provincial and territorial water managers to take a look at what has already been done in Canada and elsewhere and see if they could develop a set of interprovincial water management principles unique to the Canadian situation.

In the meantime, we are left with the provinces as the owners/managers of their internal waters constrained by the fisheries power to legislate management of the same resource as fish habitat, the federal power over navigation, the federal powers respecting boundary and international waters, and less well defined powers over interprovincial water management.

3. FEDERAL WATER LEGISLATION

3. FEDERAL WATER LEGISLATION

3.1 Introduction

Within the constitutional setting outlined in Chapter 2, the federal government has enacted a variety of laws over the years to fulfill its responsibilities. With two notable exceptions, these laws are of a narrow regulatory nature designed to prohibit or control activities that could have detrimental effects on navigation, fish populations, health and the natural environment.

Only the Canada Water Act and the Northern Inland Waters Act provide for a positive comprehensive management approach aimed at the optimization of benefits from Canada's water resources. Interestingly, both were debated and passed during the same session of Parliament in 1969-70.

There are at least 10 acts that bear directly on water quality. These include, at one end of the spectrum, the very general provisions of the Department of Health and Welfare Act that simply state that the duties and powers of the Minister extend to and include all matters relating to the promotion and preservation of health of Canadians (S. 5). In contrast, Part II of the Canada Water Act defines a detailed organizational and methodological approach to water quality management (presented in such a way, however, that it is not likely to be used). In between are a number of regulatory acts dealing with certain categories of pollutants such as nuclear wastes and other persistent toxic chemicals. Only one act provides specifically for the control of a broad range of pollutants, and the purpose of that act is to protect fish rather than man.

The following sections outline the major provisions of the more significant legislation related to water together with comments on the adequacy of the approach.

GOVERNMENT ORGANIZATION ACT (1979)
PART III
Department of the Environment

Purpose

To define the general responsibilities of the Minister of the Environment.

Provisions

Section 14 repeals Sections 5-7 of the Organization Act of 1970 and substitutes:

Section 5 defines the powers of the Minister to include:

> "(a) all matters over which Parliament ... has jurisdiction, not by law assigned to any other ... relating to:
>
> (i) the preservation and enhancement of the quality of the natural environment, including water, air and soil quality,
> (ii) renewable resources, including ... migratory birds,
> (iii) water,
> (iv) meteorology,
> (v) ... the enforcement of any rules or regulations made by the International Joint Commission ... as far as they relate to the preservation and enhancement of the quality of the natural environment,
> (vi) the coordination of the policies and programs of the Government ... respecting the ... quality of the environment."

Section 6(1) defines duties the Minister shall undertake in relation to his powers outlined in Section 5, including:

"(a) initiate, recommend and undertake programs and coordinate programs of the Government ... designed

(i) to promote establishment or adoption of objectives or standards relating to environmental quality, or to control pollution,
(ii) to ensure that new federal projects ... are assessed early in the planning process for potential adverse effects on the quality of the natural environment and that a further review is carried out of those ... probable to have significant adverse effects,
(iii) to provide ... Canadians ... information.

(b) promote ... practices ... leading to the better preservation and enhancement of environmental quality, and cooperate with provincial governments ... or persons ...

(c) advise ... agencies of the Government on all matters pertaining to ... quality of the environment."

Section 6(2) authorizes the Minister to ...

"by order, with the approval of the Governor in Council, establish guidelines (respecting environmental quality) for use by departments, boards and agencies of the Government and by (Crown) corporations and regulatory bodies."

Section 6(3) authorizes the Minister, with Governor in Council approval, to enter into agreements with the provinces.

<u>Comment</u>

The Act gives the Minister of the Environment the major federal role with respect to water and measures to control environmental quality factors that could directly or indirectly affect water quality. The Act does not go to the extent, however, of <u>requiring</u> that all federal projects

conform to environmental requirements of the Minister. Reticent agencies may only have compliance pressures applied to them through the issuance of guidelines by the Minister, on the approval of the Governor in Council.

In times of economic stress, the pressures to minimize costs may place environmental quality considerations in jeopardy with the Minister of the Environment but one among equals in a large Cabinet. In the interests of environmental quality maintenance and of assuring that all federal water related projects optimize the use of water, new legislation is desirable to require that federal projects, programs and activities likely to have significant environmental effects be subject to environmental assessment and approval of the Minister of the Environment.

CANADA WATER ACT (1970)
(Department of the Environment)

Purpose

"To provide for the management of the water resources of Canada including research and the planning and implementation of programs relating to the conservation, development and utilization of water resources."

The Act was based on perceptions that:

(a) demands on water resources were increasing rapidly and more knowledge was needed concerning their supply, demands thereon and the means for meeting the demands;

(b) pollution had become a significant threat to health, well-being and prosperity of Canadians, and that it had become a matter of urgent national concern that measures be taken in areas most critically affected; and,

(c) comprehensive programs in cooperation with the provinces were required for research and planning of water resources to ensure their optimum use.

Provisions

PART I
COMPREHENSIVE WATER RESOURCE MANAGEMENT

Section 3 authorizes the Minister to enter a variety of consultative, advisory and coordinative arrangements with provinces on national, regional or river basin bases.

Section 4 authorizes federal/provincial programs related to inventory, data collection, research, comprehensive manage-

ment planning, project design, and the implementation of plans and projects.

Section 5 provides for unilateral federal action for all or some of the functions outlined in Section 4 depending on specified conditions.

The complete range of activities is authorized for federal waters, such as in the northern territories.

Limited authority is provided for direct involvement in interprovincial, boundary and international waters where all reasonable efforts to reach federal-provincial agreements fail. For interprovincial waters, Governor in Council authority may be provided for the preparation of comprehensive management plans and the design of projects, but not their implementation. For boundary and international waters, the authority may be extended to include the implementation of plans or projects.

Section 6 provides general authority for water research, data and inventory programs.

Section 7 outlines provisions to be included in federal-provincial agreements including the sharing of assignments and costs.

PART II

WATER QUALITY MANAGEMENT

Except for federal waters, Part II applies only to waters where water quality management has become a matter of urgent national concern (S. 9(a)).

Sections 9 and 13 authorize federal-provincial agreements to designate water quality management areas and to procure the incorporation of water quality management agencies to plan and carry out programs to: determine the nature and quality of current and anticipated wastes; recommend water quality standards; the kinds and amounts of wastes that may be deposited; treatment requirements; effluent discharge fees; and, waste treatment charges.

On approval of a water quality management plan by ministers of the governments involved, a water quality management agency may be authorized to: design, construct and operate waste treatment facilities; collect waste treatment fees and effluent discharge fees; monitor water quality; inspect treatment plants; and, do such other things necessary for effective water quality management (S. 13).

Section 8 prohibits the deposit of wastes within water quality management areas except as prescribed for that area and with payment of any prescribed effluent discharge fees.

Section 11(1) provides for unilateral federal action on interjurisdictional waters of urgent national concern when all reasonable efforts to effect federal-provincial agreements have failed, or when such agreements are terminated on disagreement over water quality standards. The unilateral action may encompass all the functions outlined in Section 13 for agencies set up under federal-provincial agreements.

Section 11(2) provides for designation of water quality management areas and the incorporation of agencies for federal waters.

Section 16 authorizes the making of regulations for water quality management areas on the recommendation of the agency or jointly by the ministers who are parties to a federal/provincial agreement. Among other things regulations may cover: quantities of waste that may be discharged; water quality standards; waste treatment charges; and, effluent discharge fees.

PART III
NUTRIENTS

Part III relates to the regulation of cleaning agents and water conditioners containing nutrients that could promote aquatic plant growth and degrade the usefulness of water to man, or to animals, fish or plants useful to man.

Section 18 prohibits the manufacture or import of cleaning agents or water conditioners containing prescribed nutrients in concentrations greater than prescribed.

Section 19 allows regulations prescribing nutrients and their maximum concentrations in cleaning agents and water conditioners.

Section 20 authorizes seizure of these products believed to be in violation of the regulations.

PART IV
GENERAL

Sections 23 and 24 provide for inspectors and analysts and their duties.

Section 26 authorizes the Minister to appoint advisory committees.

Section 27 gives general authority to the Minister to publish information on the conservation, development and use of water resources.

Section 36 requires submission of an annual report to Parliament on operations under the Act.

Sections 22 to 24 relate to offenses. Anyone who deposits wastes in violation of regulations under Section 18 or who manufactures or imports cleaning agents or water conditioners in violation of regulations under Section 18 is liable to a fine up to $5,000 for each day the offense is committed.

Comment

The Canada Water Act introduced the concept of comprehensive multiple use water management to federal legislation. It supplanted the Canada Water Conservation Assistance Act under which the federal government could contribute 37.5 percent of the cost of works built for water conservation. It had been used primarily to support the construction of flood control works.

Part I of the Act permits federal cooperation with provinces in a full range of research, planning and project implementation where there is significant national interest.

The title of Part II, Water Quality Management, is unfortunate for two reasons. It incorrectly implies that water quality management is excluded from the programs authorized in Part I, and it implies that the only approach permitted under the Act is the unique detailed water quality agency concept defined in Part II.

Part II introduces the concept of incorporated agencies to manage water quality on a user-pay principle. Except federal waters, however, the approach is only applicable in areas where water quality has become a matter of urgent national concern.

When the Canada Water Bill was introduced in Parliament in 1969, some provinces felt that Part II was an affront to their pollution control programs and a threat to their jurisdiction over water. While Part II could be applied to any federal waters, it could only be applied to provincial waters the quality of which had become of urgent national concern. Since there were no water quality problems of note in the North, did this mean the federal government was about to decide that there were urgent national problems in provincial waters?

Section 11 added a double-barreled threat of unilateral action. Not only was the federal government authorized to take unilateral action on interjurisdictional waters should all reasonable efforts to obtain federal-provincial agreements fail, the unilateral action threat was present even if provinces were to enter agreements under Part II. Should such an agreement be terminated because of a failure of governments to agree on recommended water quality standards, the federal government could take over, so to speak. This provision effectively eliminated any prospect of provinces entering water quality management agreements under Part II of the Act.

Since Part II of the Act defines a specific approach to water quality management, it may well be that the same approach could not be incorporated in a federal-provincial agreement under the provisions of Part I which are less threatening to provincial sensitivities. This is

unfortunate, since the management concepts contained in Part II offer promise of bringing economic pressures to bear on the producers of waste.

A further criticism of Part II is that it is reactive, being applicable to interjurisdictional waters only when water quality has deteriorated to the extent that it has become of urgent national concern. This is in contrast to Part I that stresses a forward-looking planning approach to optimize benefits.

> IT IS RECOMMENDED that Part II of the Canada Water Act be revised to extend its applicability to areas where water quality is of significant national interest. The provision for unilateral federal action should not be similarly extended.

Adoption of this approach may require the use of provincially incorporated agencies rather than federally incorporated ones to ensure that an agency's regulations would be held valid by the courts.

Part III of the Act relating to the control of the manufacture or import of cleaning agents and water conditioners was aimed directly at controlling the phosphate contents of laundry detergents that, at the time, had been identified as a major causal factor of eutrophication of the Great Lakes.

Once the Act came into force, an appropriate regulation was made. It was not until 1976 that federal regulation of other pollutants of significant national concern, such as persistent toxic substances, became possible under the Environmental Contaminants Act. With the availability of that Act, new regulatory powers over manufacturing, processing or importing of substances containing pollutants are not required under the Canada Water Act.

ENVIRONMENTAL CONTAMINANTS ACT (1976)
(Departments of Environment and National Health & Welfare)

Purpose

The purpose of the Act is to protect human health and the environment from substances that contaminate the environment.

Provisions

Section 3(1) provides for importers, manufacturers or processors of substances or classes of substances to provide the Minister with cata on the amounts involved, following publication of a notice by the Minister.

Section 3(3) permits the Minister of the Environment or Minister of National Health to undertake research and make recommendations on substances suspected of entering the environment that may constitute a danger to human health or the environment.

Section 3(4) allows the two ministers to appoint committees respecting measures to control any substance or class thereof, in the environment, to provide advice and to publish reports and recommendations.

Sections 3(6) and (7) encourage cooperation with other federal departments and other governments.

Section 3(8) provides for agreements with provinces to conduct investigations on substahces suspected to constitute a danger to health or the environment.

Section 4 provides for the Ministers of the Environment and National Health and Welfare to take certain actions when they believe a substance is entering the environment,

or will, in an amount, concentration, or under conditions that they believe constitutes a significant danger to human health or the environment. They may:

- publish notice requiring anyone using the substance, or class thereof, in commercial, manufacturing or processing activities to notify the Minister of the Environment;

- require information on the substance, or class thereof, from the user; and,

- require importers and manufacturers of the substance or any product containing it to conduct tests specified by the Ministers.

Section 4(6) requires first time manufacturers and importers of chemical compounds in amounts greater than 500 kilograms to notify the Minister of the name of compound, the amount manufactured or imported and information respecting any danger to human health or the environment.

Section 7(1) provides for a formal schedule of substances, or classes thereof, that the two ministers believe are entering the environment, or will, in quantities, concentrations or under conditions that constitute a significant danger to Canada or an area thereof.

Section 8(1) prohibits release into the environment, in the course of commercial, manufacturing or processing activities, of substances on the schedule except in accordance with regulations made under Section 18,

including:

- the maximum quantity or concentration that may be released;

- conditions under which there may be no release; and,

- geographical areas where the substances may not be released

Section 8(2) prohibits for commercial, manufacturing or processing uses the import, manufacture, process, sale or knowing use of substances on the schedule in Canada, or in geographical areas prescribed by regulation under Section 18.

Section 8(3) exempts from the strictures of S. 8(2) materials that include scheduled substances adventiously and in a quantity or concentration consistent with good manufacturing practices.

Section 8(4) prohibits the import, manufacture or knowing sale of products containing a scheduled substance in a quantity or concentration exceeding the prescribed maximum.

Section 8(5) provides for fines up to $100,000 or two years imprisonment for contraventions of Section 8.

Section 5(1) requires the Ministers of the Environment and National Health and Welfare to offer to consult with provinces and other federal agencies before recommending the addition of a substance to a schedule to regulate its release, import, manufacturing, processing and content in

products. The purpose of consultation is to determine whether provinces will take appropriate action to eliminate the perceived danger to human health and environment.

Section 5(2) requires the Minister of the Environment to publish proposed orders and regulations so that objections may be filed (S. 5(3)).

If objections to proposed orders and regulations are filed, the Ministers are required under Section 6 to set up Environmental Contaminants Boards of Review to inquire into the nature and extent of the danger posed by the substance in question, hear representations from interested parties, and submit a report with recommendations to the Ministers. The report must be published.

Section 7(3) provides for by-passing the consultation process in emergencies, although provision is made for the filing of objections (S. 7(4)) and appointment of Boards of Review as required (S. 7(5)).

Sections 9 and 10 make appropriate provisions for analysts and inspectors and their authority.

Sections 11, 12 and 13 provide for seizure, retention, return or forfeiture of contaminant substances.

Regulations

To date, five substances or classes of substances have been placed on the Schedule and are regulated. These are: Chlorobiphenyls (PCB's), mirex, polybrominated biphenyls (PBB's), polychlorinated terphenyls (PCT's), and chlorofluorocarbons (CFC's).

Comment

Unlike the Pest Control Products Act that requires manufacturers of new pesticide formulations to seek registration of their products before they may be sold and used in Canada, the Contaminants Act places the onus for action on government. The Ministers of the Environment and National Health and Welfare must come to the belief that a substance is entering the environment, or will do so, in a manner that they believe constitutes, or will constitute, a significant danger to human health or the environment (S. 4). Only then can they require importers or manufacturers to conduct tests to determine the safety of a product so that a judgment may be made concerning its use in Canada. Furthermore, manufacturers and importers are not required to report their use or sale of new substances unless more than 500 kilograms are involved on an annual basis (S. 4(6)). It is conceivable, therefore, that significant amounts of persistent toxic substances could build up in the environment unnoticed over a period of years.

It is probable that the Act was drafted in this fashion with the knowledge that a comprehensive product approach process would impose long delays on the use of new chemicals and would undoubtedly overwhelm the limited toxicological resources of the government. The adopted approach does, however, accept a risk -- a risk that government scientists will suspect the dangers inherent to the use of certain classes of chemicals, require appropriate testing, and impose indicated controls before significant danger to the environment or human health occurs.

It would seem appropriate at this stage to place the full responsibility for signalling risks and proving the health and environmental safety of chemical substances on the industrial and commercial users. Such a step would more fully reflect the government's objective of protecting environmental quality and to have the user pay to maintain that quality. It would also bring the Contaminants Act more in line with the Pest Control Products Act.

> IT IS RECOMMENDED that the Environmental Contaminants Act be revised to establish a chemical substances registration process under which anyone planning to engage in any commercial, manufacturing or processing activities involving chemical substances new to Canada would be required to notify the Minister of the Environment and to conduct appropriate tests to determine its safety to human health and the environment, upon which registration decisions may be based. The new Act should also provide for the evaluation and registration of chemical substances already in use.

INTERNATIONAL RIVER IMPROVEMENTS ACT (1955)
(Department of the Environment)

Purpose

To provide for the regulation of construction, operation and maintenance of works on international rivers that would alter natural flows and interfere with use of the rivers outside Canada.

Provisions

Section 3 provides for regulations respecting the construction, operation and maintenance of international river improvements, the licensing thereof, and the exempting of any works from the operation of the Act.

Section 4 specifies that a licence is required to construct, operate or maintain an international river improvement.

Section 5 makes it an offense to violate the Act or any regulation with a penalty of up to $5,000 or five years imprisonment, or both for conviction on indictment or up to $500 and/or six months on summary conviction.

Section 6 authorizes the Governor in Council to order any international river improvement in violation of the Act or regulations forfeited to Canada and removed, destroyed or otherwise disposed of, with the costs involved being recoverable from the owner.

Section 7 exempts works constructed under a federal Act, situated within boundary waters, or built solely for domestic, sanitary, irrigation or other similar consumptive uses.

Section 8 binds the provinces.

Section 9 notes the applicability of provincial laws as long as their provisions are not in conflict with this Act.

Comment

This Act was passed when Canada found itself confronted by the Government of British Columbia that did not wish to await the Columbia River studies (IJC) and proposed to build a major dam on the Columbia River for a purpose not thought to be in the best interests of Canada.

LaForest (1968) felt that constitutional justification for the Act probably rests under the peace order and good government power since obstruction or diversions of international rivers could cause serious international incidents involving the country as a whole. He noted that the approach is

> "reinforced by other doctrines tending to take out of provincial control any matters affecting the nations sovereignty." (p. 344)

The exclusion of irrigation works from the provisions of the Act is interesting since such works could certainly alter natural flows and interfere with the downstream use of a river in the United States. It is probable that political pressures resulted in this exclusion to limit the range of applicability of an Act that was in fact aimed at one particular proposed storage reservoir.

The Act appears to be further limited in not applying to water quality issues.

MIGRATORY BIRDS CONVENTION ACT
(Department of the Environment)

Purpose

To ratify and implement the Migratory Birds Convention with the United States.

Provisions

Section 4(1) provides for the making of regulations "to protect the migratory game, migratory insectivorous and migratory nongame birds...".

Regulations

One regulation provides that

> "No person shall knowingly place, cause to be placed or in any manner permit the flow or entrance of oil, oil wastes or substances harmful to migratory waterfowl into or upon waters frequented by migratory waterfowl or waters flowing into such waters or the ice covering such waters."

Comment

The articles of the Convention define migratory birds, close hunting seasons, special provisions for wood and eider ducks, taking of nests and eggs, export prohibitions, and provisions to kill protected birds under extraordinaty conditions. No references are made to pollution or the regulation thereof. The Act does, however, provide regulatory authority for "any purpose that may be deemed expedient for carrying out the

intention of this Act and the said Convention". These, however, must be subject to the terms of the Convention.

FISHERIES ACT (1867-1978)
(Department of Fisheries & Oceans
Department of the Environment: Section 33)

Purpose

To provide for the protection and conservation of fisheries.

Provisions

Three important sections of the Act are directly related to fish habitat protection. Section 20 deals with obstructions to fish passage. Section 31 deals with protection of habitat from physical disruption, while Section 33 relates to the deposit of deleterious substances in water. Section 34 provides for regulations.

Section 20 authorizes the Minister to require the construction, operation and maintenance of fishways or canals around dams or other obstructions. Where fishways are inappropriate, the owner of a dam may be required to provide funds for the construction and operation of hatcheries for maintaining the annual return of migratory fish.

The Minister may order the removal of unused obstructions and recover the costs of removal.

Section 31 provides that "no one may carry on any undertaking that results in harmful alteration, disruption or destruction of fish habitat" unless approved by the Minister or by regulations under the Act.

Habitat is defined broadly to include spawning, nursery, rearing, food supply and migratory areas depended upon by fish directly or indirectly.

Fines of up to $50,000 for a first offense and up to $100,000 for suceeding offenses are provided for.

Section 33.1(1) authorizes the Minister to require sub-mission of plans of work and information relating to the fish habitat likely to be affected by a proposed activity. The Minister may require modifications to the plans to meet fish habitat requirements, but shall first offer to consult with interested provinces and federal agencies.

Sections 33(1) and (2) prohibit the deposit of deleterious substances "in water frequented by fish, or in any place or manner where such deleterious substances ... may enter such waters", unless in conformance with regulations under the Fisheries Act or other federal Act.

Penalties of up to $50,000 for a first offense and up to $100,000 for succeeding offenses are provided for. The owners of the deleterious substance deposited are liable for any consequent loss of income by commercial fishermen.

Section 33(11) defines deleterious substances broadly to include any substance or water containing a substance, or heated water, that if added to a watercourse would be harmful to fish.

Regulatory authority is provided to exempt certain deleterious substances from deposit in specified waters, in specified quantities or concentrations and under specified conditions.

Section 33.1(1) authorizing the Minister to seek plans of proposed undertakings and to order changes therein applies with respect to the deposit of deleterious substances as it does to habitat disturbance.

In addition to providing for inspectors and their powers, Section 33.2 requires the reporting of spills or imminent spills of deleterious substances into waters and requires the owner or operator to take all reasonable means to prevent or counteract any spill that does occur.

Again, fines are stipulated for those failing to submit requested plans and reports or failing to carry out undertakings in accordance with approved plans.

Regulations

(a) Deleterious Substances

Effluent quality regulations have been prescribed for the pulp and paper; chlor-alkali; petroleum refining; metal mining; potato processing; and, meat and poultry products industries.

(b) British Columbia Gravel Removal Order,

This regulation prohibits the removal from or disturbance of gravel in spawning grounds frequented by fish without a permit.

(c) Fishway Obstructions Removal Regulation,

This regulation provides for the removal of any natural or casual obstruction interfering with the free passage of fish.

Comment

The Fisheries Act suffers in that it deals with only one component of natural resource management, the punitive regulatory component. There are no provisions for habitat

inventory, planning habitat requirements, or development. This is a major deficiency since fish habitat is a resource within a resource, the water resource, from which man makes many demands in addition to the propagation of fish. While the restrictive approach of the Fisheries Act can protect fish habitat from man's non-fisheries uses to a certain extent, it cannot yield appropriate management of the resource in concert with man's other demands. By its very nature, the restrictive approach becomes a rearguard action, unless it were assumed that fish production was the country's pre-eminent demand on water resources. The restrictions could be so numerous as to prevent many other water uses.

Some federal legislation does in fact suggest that the welfare of fish takes procedence over man. The Northern Inland Waters Act (NIWA) provides in Section 3(3) that none of its provisions or regulations or licences issued under it may authorize the alteration, diversion or storage of water in contravention of provisions of any other Act. Essentially, such provisions install the Minister of Fisheries as the judge over water resource development and use.

These provisions along with the lack of recognition in the Fisheries Act of multiple or integrated resource management sometimes place fisheries officers in difficult confrontations with the proponents of other water uses, and with federal and provincial agencies with other responsibilities. For instance, the legislated objective of the territorial water boards under Section 9 of the NIWA is to provide for the conservation, development and use of water in a manner that will yield optimum benefits. Obtaining that objective will at times be detrimental to fish habitat.

The problem is one of objectives -- whether or not the overall objective is to benefit man. If it is, it should be possible to make fish habitat management compatible with other aspects of water resource management.

Looking back to 1867, when responsibilities for fisheries and navigation were vested in the federal government, it is evident they were so assigned because of national importance to Canadians at the time, for their commercial and subsistence uses. The definition of "deleterious substance" in Section 33(11) is not as clearly supportive of man's benefit as the end objective of fisheries, but at least he is mentioned. The definition talks of degradation of the quality of water "so that it is rendered ... deleterious to fish or fish habitat, or to the use by man of fish ...".

The definition of "waste" found in the Canada Water Act and the Northern Inland Waters Act clearly places the interests of man as primary. It talks about things that if added to waters could be "detrimental to their use by man or by any animal, fish or plant <u>that is useful to man</u>." Adoption of a similar definition for deleterious substances in the Fisheries Act would help clear the way for adoption of a comprehensive and multiple-use approach to fisheries management.

Some might argue that the adoption of a multiple/integrated-use policy for fisheries planning and management could mark a significant shift in the constitutional setting. Were the benefits from fisheries to be weighed against the benefits of other water uses in a development proposal, fisheries would sometimes come out the loser.

The argument might be that this could not be allowed to happen because of the federal jurisdictional primacy for fisheries.

History demonstrates, however, that the fishery has come out the loser more often that not with the present legislative approach. Were the Fisheries Act amended to provide for the planning and management of fish habitat in conjunction with other water uses, the result would be a more effective voice for fisheries interests and a stronger likelihood of achieving the illusive optimum benefits from this habitat/water resource management.

> IT IS RECOMMENDED that the Fisheries Act be changed to add provisions to Section 31 to allow for the conservation and development of fish habitat through comprehensive management progams in a multiple or integrated water resource context. The provision should be such that the existing prohibitory sections of Section 31 would only be applicable in the absence of the new multiple-use planning approach.

Within any resource management context the suitability of national effluent standards to control the quality of fish habitat or water quality in general has long been debated. National standards result in strictures too weak in some locations, too strong in others. When first proposed, the Minister of the day talked about preventing the development of "pollution havens" in Canada. Perhaps the interest was more one of equalizing waste treatment costs across Canada than of protecting the fisheries. Confronted with a superior jurisdictional power, provinces were willing to accept national standards only if they were to be national minima. Provinces would thus retain the authority to deal with individual local works and undertakings adding requirements more stringent than the national standards if required.

National standards do have their appeal. They readily receive public acceptance since the federal government is generally expected to take a national approach to things. They give the impression of equitable treatment to polluters. They are easy to apply to individual undertakings as opposed to devising site-specific requirements for each waste discharge. They provide industrial planners with at least an indication of what to anticipate from pollution control agencies. They also provide provincial authorities with solid bases on which to add more stringent site-specific requirements as required. Finally, the federal government traditionally adopts national regulations, being loath to allow its employees regulatory discretion.

In spite of these advantages, the superior approach to maintaining fish habitat quality at satisfactory levels would be to base effluent requirements on water quality objectives established for the receiving waters. This would allow incorporating into the effluent quality formula the natural quality of watercourses, their assimilative capacities for certain wastes, the sensitivities of native fish populations, and the impacts of waste discharges already present. The Fisheries Act requires amendment to allow adoption of this approach.

> IT IS RECOMMENDED that the national approach to effluent requirements be changed from one of required standards to one of basic effluent treatment guidelines.

> IT IS FURTHER RECOMMENDED that the Fisheries Act be amended to allow for adoption of site-specific industrial and municipal effluent requirements for the protection and conservation of fisheries in a multiple/integrated use water management context.

CANADA SHIPPING ACT (1970-71-72)
PART XX
(Ministry of Transport)

Purpose

To provide for the control of pollution from ships (particularly oil tankers), and the recovery of costs and damages from polluters and a specially created fund.

Provisions

Section 728(1) provides for regulations prohibiting the discharge of specified pollutants from ships.

Section 728(2) requires the master of a ship to report actual and anticipated spills of pollutants.

Section 729(1) authorizes the removal or destruction of ships in distress that are discharging pollutants, or are likely to.

Section 730(1) authorizes regulations prescribing substances as pollutants; defining spill reporting procedures; respecting all aspects of navigation; prescribing the types and amounts of pollutants carried; equipment to contain and clean up spills; retention of oily wastes; and, compulsory navigation routes.

Sections 731 and 732 provide for the appointment of pollution prevention officers and their duties including that of ordering ships to report positions and to assist in a clean-up operation. Authority to seize ships believed to be in violation of Part XX is provided under Section 760(1).

Section 734(1) makes owners of tankers and cargo owners jointly and severally liable for costs of pollutant clean-up and actual losses to Canada, a province or a person.

Section 746(1) specifies that personal losses may include actual and anticipated income losses of fishermen.

Section 735(1) in compliance with international convention defines the limited amounts recoverable from ship and cargo owners where an incident occurs without actual fault on their parts.

Section 736(1) requires ship and cargo owners to provide evidence of financial responsibility for the amounts indicated in S. 735(1) prior to importing or exporting pollutants in bulk.

Section 737(1) establishes a Maritime Pollution Claims Fund to pay unrecoverable clean-up costs, damages and fishermen's income losses.

Section 748(1) provides for contributions to the Fund by regulation up to 15 cents per ton of oil imported or exported by ship.

Section 738 provides for an Administrator of the Fund to review and settle claims against it.

Punitive features of Part XX include fines up to $100,000 for discharging pollutants contrary to regulation or for failing to report an actual or anticipated spill, or for failing to meet other regulations under S.730.

Regulations

A variety of regulations have been issued respecting safety in loading and unloading pollutants, navigation by tankers, maintenance of pollutant containment and clean-up equipment at loeading facilities and on tankers, the safe discharge of oily mixtures and the discharge of water ballast.

Comment

Part XX of the Shipping Act applies to all Canadian waters excepting certain shipping safety control zones in the arctic that are regulated under the Arctic Waters Pollution Prevention Act.

The novel provision of the Maritimes Pollution Claims Fund should be considered for application to other potential pollution sources where the possibility exists that the responsible party cannot be brought before the courts or where there is a risk that the responsible party would be unable to defray pollution clean-up costs and related damages. The concept has already been recommended for adoption with respect to the long term protection of Government and individuals from possible pollution from abandoned mine operations (Mactavish, 1984).

NAVIGABLE WATERS PROTECTION ACT
(Ministry of Transport)

Purpose

To protect the navigability of watercourses.

Provisions

Section 5(1) provides that

> "no work shall be built or placed in, upon, over, under, through or across any navigable waters unless the work and the site and plans thereof have been approved by the Minister ..."

Section 6(1):

> "Where any work ... is built or placed without having been approved ... the Minister may
>
> (a) order the owner of the work to remove or alter the work,
> (b) ... remove and destroy the work ... and
> (c) order any person to refrain from proceeding with the construction of the work ..."

Section 9(3):

> "Where in the opinion of the Minister an existing lawful work has become a danger to or interference with navigation ... any rebuilding, repair or alteration shall be treated in the same manner as a new work."

Section 19:

> "No person shall throw or deposit or cause, suffer or permit to be thrown or deposited

> any sawdust, edgings, slabs, bark or like rubbish of any description whatever that is liable to interfere with navigation ..."

Section 20 prohibits the deposit of

> "any stone, gravel, earth, cinders, ashes or other material or rubbish that is liable to sink to the bottom in any water any part of which is navigable or that flows into any navigable water ..."

Section 23 allows the Minister to designate places where rubble or other materials may be deposited.

Comment

The Act provides strong powers to the federal government to protect the navigability of waters in harmony with its constitutional authority. The terms of the Act were not applied, however, with respect to the building or the Bennett Dam in the late 60's, to the filling of its resevoir or to the operational regulation of its flow, all of which have influenced navigation. Even had the Act been applied, however, it is doubtful if such application could have prevented the ecological consequences in the Peace-Athabasca Delta. Such concerns are beyond the purview of the Act which is the maintenance of navigability.

PRAIRIE FARM REHABILITATION ACT (1935)
(Department of Agriculture)

Purpose

To provide for the rehabilitation of drought and soil drifting areas in Manitoba, Saskatchewan and Alberta.

Provisions

Sections 3 and 4 provide for Governor in Council appointment of Prairie Farm Rehabilitation Committees to advise the Minister (currently, Agriculture) on methods

> "to secure rehabilitation of the drought and soil drifting areas ... and promote ... systems of farm practice, tree culture, water supply, land utilization and land settlement that will afford greater economic security ..."

Sectiom 7 provides for regulations

> "for the effectual execution and working of this Act and the attainment of the intention and objects thereof."

Section 9 authorizes the Minister to

> "undertake the development, construction, promotion, operation and maintenance of any project or scheme ... by virtue of this Act, or enter into agreements with any province, municipality or person with respect thereto."

Section 9(2) requires that all single projects involving more than $15,000 in any fiscal year receive Treasury Board approval.

Comment

The Prairie Farm Rehabilitation Act is quite different from other federal water legislation. Rather than a management or regulatory Act, the PFRA established an agency as a water developer/operator, delivering water to farmers, groups of farmers and farm-based municipalities.

The Act is somewhat of an enigma 50 years after it was enacted. The original drought crisis that spawned it has long since passed and much of the original task has been completed. The Act applies to a small portion of Canada's farm areas. It does not extend to all areas that experience drought conditions.

The range of programs provided by PFRA could be provided by traditional federal agencies, or by provincial agencies perhaps with the cooperation of federal departments of Agriculture, Forestry and Environment. (This is discussed in more detail in Chapter 10.)

The archaic nature of the Act is found in Section 9 that requires each project involving more than $15,000 to be approved by the Treasury Board.

If the concept of the Prairie Farm Rehabilitation Act is to be maintained, the Act and agricultural policy should be changed to allow drought-proofing projects to be delivered to drought-prone farming regions throughout Canada. The Treasury Board approval strictures should also be brought up to date.

ATOMIC ENERGY CONTROL ACT (1953)
(Atomic Energy Control Board)

Purpose

To provide for the control and supervision of the development, application and use of atomic energy ...

Application

The Act relates to radioactive substances and to any other substances, such as heavy water, that the Board may designate as required for the production, use or application of atomic energy.

Provisions

Section 4 establishes the Atomic Energy Control Board to include the President of the National Research Council and four others appointed by the Governor in Council.

Section 9 authorizes the Board, with the approval of the Governor in Council to make regulations:

(a) for developing, controlling, supervising and licensing the production, application and use of atomic energy;

(b) respecting mining and prospecting for prescribed substances; and,

(c) regulating the production, import, export, transportation, refining, possession, ownership, use or sale of prescribed substances and any other things the Board may decide are used for the production or use of atomic energy.

Section 17 declares that all works and undertakings for

(a) the production, use and application of atomic energy;

(b) research and investigation respecting atomic energy; and,

(c) the production, refining or treatment of prescribed substances,

are works for the general advantage of Canada, and are therefore, under federal jurisdiction.

Comment

The AEC Act thrusts another federal agency into the realm of pollution control for uranium mining, heavy water production, and nuclear electric plants. Relationships with Environment Canada and provinces are discussed in Chapter 8.

4. ORGANIZATION

4. ORGANIZATION FOR WATER MANAGEMENT

4.1 Introduction

Water management gained prominence among federal endeavours in natural resources late in 1966 when the Water Resources Branch was moved from Northern Affairs and National Resources to Energy, Mines and Resources where it was combined with the marine sciences and hydrogeological groups. Water management was accorded the status of a departmental sector headed by an assistant deputy minister.

The Second Session of the 28th Parliament (1969-70) was historic for the attention given to water matters. The Canada Water Act, Northern Inland Waters Act, Arctic Waters Pollution Prevention Act and amendments to strengthen the Fisheries Act and the Canada Shipping Act were all enacted.

In 1970, through a Government Reorganization Act, the Department of Environment was established, bringing together much of the Government's expertise on environmental quality management. Fisheries, the water sector of Energy, Mines and Resources, part of the public health engineering group of National Health and Welfare, and the meteorological services of Transport were brought together with other groups including the Canadian Forestry Service and the Canadian Wildlife Service. The prominence of water management began to wane as environmental management began to emerge as a more integrated approach to dealing with problems of water, air and land pollution. An Environmental Protection Service was formed within the new department, assuming the functions of other sectors for the control of pollution. The status of the water management functions dropped a notch in the hierarchy of things to the level of a directorate, reporting with several others to an assistant deputy minister.

The consolidation of agencies with environmental quality mandates weakened in 1977 with the departure of the fisheries and marine sciences services to form the present Department of Fisheries and Oceans. Notably, however, they left behind the administration of Section 33 of the Fisheries Act dealing with water pollution control.

Organizational changes will continue to occur from time to time as the Government identifies new priorities and responds to new challenges. While such changes occur, it is essential not to lose sight of basic objectives and policies that should provide a measure of consistency to the overall thrust of the Government's programs related to water resources. Interdepartmental cooperation will continue to be a vital element of the Government's management system. Emphasis must be placed on strengthening coordination systems and identifying centres of responsibility.

4.2 Current Departmental Roles

Environment Canada has the central managerial-type role among departments involved in water resources management. It is responsible for the Government's policies and programs for both water quantity and quality. It administers the Canada Water Act, International Rivers Improvement Act, Environmental Contaminants Act (with National Health and Welfare), Section 33 of the Fisheries Act (pollution control), the Migratory Birds Convention Act, and the departmental Act that bestows authority for coordination of the Government's environmental programs. Responsibility for meteorology also rests with the Department.

Within Environment Canada, there is a division of responsibilities between two services: the Environmental Conservation Service (ECS) and the Environmental Protection Service (EPS). The ECS, through its Inland Waters Directorate,

is responsible for the Canada Water Act and administers all aspects of the Department's roles respecting water quantity and quality except the regulatory aspects of water quality. The EPS carries out that role integrated with air and land pollution control. It is responsible for waste treatment technology development, technology transfer and the formulation of effluent quality regulations, guidelines and codes of good practice. It administers Section 33 of the Fisheries Act, the Environmental Contaminants Act, and advises the Atomic Energy Control Board on environmental protection aspects of the nuclear industry.

Several other departments also play key regulatory roles with respect to specific heads of federal jurisdiction. These include:

(a) Fisheries and Oceans	- fish habitat management
(b) Transport	- navigation and shipping, including pollution control
(c) National Health & Welfare	- human health aspects of drinking water - Environmental Contaminants
(d) Atomic Energy Control Board	- pollution from nuclear facilities

Others have direct operational foles in water management:

(a) Public Works	- operation of certain dams and canals, dredging of shipping channels
(b) Transport	- operation of navigational systems
(c) PFRA	- operation of reservoirs and irrigation systems
(d) Indian Affairs & Northern Development	- water management on Indian Reserves, Yukon and NWT - impacts of federal national policies on territorial water management practices

Another group has important interests in water as developers in support of industries:

(a) Agriculture	- water for farm productivity
(b) PFRA	- water supplies for farms and farm-based communities
(c) Energy, Mines and Resources	- water for energy production
(d) Regional Industrial Expansion	- water supplies for individual industries and community infrastructure

Still others have special interests that do not fit the category of general management, or the specific component of regulation, operation or development:

(a) Northern Affairs	- impact of federal national policies on territorial water management practices
(b) External Affairs	- monitoring and negotiation of international treaties and agreements
(c) IJC (Canada)	- response to Canada-U.S. references under Boundary Waters Treaty
(d) Emergency Planning	- coordination of flood relief and disaster compensation
(e) Science and Technology	- federal research and development policies

While a variety of reorganizational possibilities could be considered, the present situation offers a reasonable situation and provides important separation of the managerial and developmental roles. A management agency should not be placed in the position of judging the merits of its own development proposals.

One could question the separation of the regulatory aspects of water quality management from the monitoring, research, planning and allocation aspects. On the other hand, there are efficiencies in integrating the pollution regulatory functions for air, water and soil. It remains important, however, that the pollution regulator work to achieve the requirements of other agencies rather than attempt to determine its own needs. Agencies such as National Health and Welfare, Fisheries and Oceans, Agriculture, and the Canadian Wildlife Service have the expertise to determine water quality requirements. That expertise must not be duplicated in the control agency. The major requirement is achieving and maintaining close cooperation among all the many agencies involved so that the regulator, the Environmental Protection Service, is conversant with the water quality requirements of water users.

4.3 Interdepartmental Coordination

In 1968, when the Government was considering the Canada Water Bill, it recognized the need for improved interdepartmental cooperation and established the Interim Interdepartmental Committee on Water (ICW). The "interim" label presumed confirmation as a continuing committee following proclamation of the Canada Water Act. Terms of reference for the new ICW were:

> "to consider and approve all federal government water programs until a permanent mechanism was established, and that a committee of ministers should formulate a permanent mechanism for resolving interdepartmental conflicts on water programs; in the light of the proposed Canada Water Act and national water policy."

The committee of ministers were never formed. Conflicts that were not resolved by the ICW itself presumably were worked out on an informal basis among ministers or on a formal basis at meetings of Cabinet committees.

After the Canada Water Act became law, no action was taken to reconfirm the status of the ICW. It continued to perform its coordination and program approval functions through its original terms of reference until, in 1975, the Committee itself adopted revised terms of reference, in the understanding that they fulfilled the intent of the original 1968 Cabinet directive. These were:

> "1. To consider and recommend on all federal water policies and programs in order that all federal efforts are directed towards the same objectives.
>
> "2. To consider and advise the Minister of the Environment in regard to any agreement entered into with the provinces respecting the formulation and implementation of comprehensive basin and water quality management plans.
>
> "3. To consider and advise on other water policy and program matters of interdepartmental significance referred to it by any federal agency.
>
> "4. To conduct such studies as may be necessary to enable the Interdepartmental Committee on Water to advise or make recommendations to the Minister with respect to the formulation, coordination and implementation of water policies and programs in Canada.
>
> "5. To report when necessary to the Interdepartmental Committee on the Environment."

The Interdepartmental Committee on the Environment, established in 1973 to propose ways and means of consolidating and strengthening the coordination process, soon became defunct. The ICW continued to report to the Cabinet through the Minister of the Environment.

It is notable that the revised terms of reference provide for recommendations on all federal water policies and programs rather than approval. The choice of words is not really significant since it is the Cabinet that makes final decisions, not committees of officials.

In its early days, the ICW played a significant role. Major federal initiatives were being developed including the Canada Water Bill, Northern Inland Waters Bill, amendments to the Fisheries Act and the Shipping Act. The first comprehensive river basin planning agreements were being negotiated with provinces. The need for coordination was strong and the ICW played its role.

As time passed and fewer major initiatives were being proposed by departments, the ICW appeared to some to have waned in importance. Its continuing significance is attested to, however, by the apparent wish in some quarters that it would simply fade away. There have been attempts to "end run" the Committee and seek Cabinet approval of programs without ICW recommendation. In the last few years, for example, PFRA has attempted to have irrigation programs approved without interdepartmental review. Fisheries and Oceans was reluctant to have their habitat policy proposal reviewed by the ICW.

It is essential that an effective means exist to coordinate and integrate federal water programs, particularly in the current climate of financial restraint in combination with the growing complexity of water issues -- water shortages in the west and water pollution from non-point sources. The interests of the agricultural water developer, energy proponent, fish habitat manager and industrial stimulator must be drawn together in a forum to foster mutual understanding and cooperation within a consistent federal water policy framework.

IT IS RECOMMENDED that the federal government formally reconfirm the existence of the ICW with the 1975 terms of reference, but excluding references to the defunct Interdepartmental Committee on the Environment.

To ensure the effectiveness of the Committee, both the Privy Council Office and the Treasury Board should be admonished not to consider water program initiatives of departments without the advice of the ICW or the Minister of the Environment.

If the ICW is to review and recommend on federal water initiatives, however, it is encumbent on the Government to draw up a considerably more explicit and detailed water policy than it now has. The last policy statement published was in 1978.[1] For the most part, its 16 components are but general statements of principle. For example:

> "The federal government is committed to the conservation, development and use of Canadian water resources for the greatest social and economic benefit of Canadians, including both present and future generations."

Such statements are fine as far as they go, but they do not go far enough. Indeed, there are indications that they are primarily a collection of broad statements to support existing programs, rather than a comprehensive exposition of policy. For example, policy no. 3 states that:

> "The federal government is committed to the restoration and protection of water quality and the enhancement of aquatic

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[1] Environment Canada, 1978. A vital resource: federal policy statement on inland waters.

> ecosystems through the development of water quality objectives to protect water uses, the application of national effluent regulations and guidelines to control pollution discharges at source; and the control of nutrients and chemical substances which can become dispersed in the environment."

The "development of water quality objectives" suggests the use of site-specific requirements for the treatment of industrial and municipal wastes. The "application of national effluent regulations and guidelines" as a principle pollution control strategy does not lead to the attainment or maintenance of ambient water quality objectives. There are two different approaches here, one supported by the concepts of the Canada Water Act, and the other by the concepts of the Fisheries Act. They can be made compatible if articulated in more detail and supported by other measures; but the federal water policy statement does not provide that measure of articulation and integration.

What is required is a set of working policies integrated into a comprehensive package. A working policy should contain three components: an objective; a strategy for achieving the objectives; and, the timeframe of priority assigned to reaching the objective. These exist for individual federal programs, but they remain to be integrated.

The development of an action-oriented federal water policy should take place in an interdepartmental forum to ensure an end result that all agencies contribute to and can support.

> IT IS RECOMMENDED that the ICW be charged with developing and proposing a set of water management objectives, strategies and priorities that integrate the interests of the water manager, water developer, and water user departments.

4.4 Federal-Provincial Cooperation

There are a variety of forums to effect federal-provincial cooperation. The Canadian Council of Resource and Environment Ministers (CCREM) provides what might be described as a neutral forum at the national level. It is a consultative body of ministers from the provincial and the federal governments. Territorial Government ministers usually attend as well. As a non-voting forum, it has proven itself useful in developing common approaches to some difficult issues. Currently the CCREM has a task force of officials working to collate water quality objectives used in Canada in an effort to produce common objectives for use across the country.

The Federal-Provincial Advisory Committee on Environmental and Occupational Health advises ministers of Health on water quality issues, including drinking water requirements. Under the Canada Water Act, at the bilateral level, a variety of options are available, ranging from formal meetings of ministers to informal meetings of provincial and federal regional staff. At the more formal level, Consultative Committees on Water were established in the '70's to provide for review of water management issues by senior officials of each province and Environment Canada. Used fairly frequently a decade ago, few Consultative Committees continue to meet, apparently because neither side has felt the need to initiate meetings at this level.

Briefs submitted to the Inquiry from some provinces suggest an interest in renewing such senior level discussions. It is essential that senior provincial officials have access to senior staff in Ottawa, for it is there that federal policies are made. To remove any uncertainty about its willing to consult:

> IT IS RECOMMENDED that the deputy minister of Environment Canada write to his counterpart in each province expressing interest in revitalizing the Consultative Committees on Water.

An interesting initial subject for discussion at such meetings would be the forthcoming report of the Inquiry on Federal Water Policy.

Other bilateral forums exist under federal-provincial Accords for the Protection and Enhancement of the Environment. These Accords, signed with eight of the ten provinces at the ministerial level in 1975, provided for cooperative efforts in environmental quality management and bilateral committees to oversee the implementation of the Accords and to consult on environmental matters. The Accords are commented on in more detail in Chapter 8.

At the specific program level, each new federal-provincial agreement provides for some sort of bilteral arrangement to manage the program. Perhaps the issue here is not the availability of coordinating forums, but the fact that different cost-sharing arrangements are available depending on the federal department involved. Under the Canada Water Act, various planning and flood control agreements normally provide for 50-50 cost-sharing. Water quantity and quality monitoring agreements have sharing formulas determined by the relative federal and provincial interests in the data from each station. On the other hand, federal-provincial water development agreements offered by Regional Industrial Expandion or PFRA may provide for a significantly greater proportion of federal monies. This can cause difficulties for interdepartmental coordination of programs, with provinces playing one off against the other, seeking the sweetest deal.

An important distinction to be maintained with respect to cost-sharing is one between water management and water development programs. All federal water planning programs that provide for cost-sharing should employ the same formula. Different ratios that may apply to water development projects should be justified on grounds other than water management policy. Provinces should be kept fully informed of the logic behind the various cost-sharing formulas adopted by federal agencies.

Perhaps the most important aspect of federal-provincial consultations from the provincial point of view is timing. Too often the consultation turns out to be an explanation of new federal policies or programs after decisions have been made in Ottawa. Provinces need to be more closely involved in the development of federal water policies that influence provincial water management. In spite of protests about confidentiality, it should be possible to discuss concepts under consideration for new federal legislation or programs without violating the rules of Cabinet secrecy.

5. WATER MANAGEMENT DATA - QUANTITY

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5.1 The Policy

In January 1975, the federal government issued an Order-in-Council committing itself to a national water quantity survey with specific guidelines for determining the government's interests in each gauging station. Stations are to be designated as of federal interest, federal-provincial or provincial. This classification determines the role of the federal government in constructing, operating and paying the costs of gauging stations. (The situation is different in Quebec where the province operates most of the network and the federal government pays the Province in accord with its interests in each station.)

The objective of the Water Quantity Management Data program of Environment Canada is:

> "to collect, process, analyze, store, interpret and provide complete and meaningful hydrometric (streamflow, water level, sediment, etc.) data on Canadian waters in cooperation with the provinces to aid in the conservation, development and use of Canadian water resources for the greatest social and economic benefit of Canadians, including both present and future generations."

The Survey network gathers data on streamflow, water levels, and to a limited degree, sediment transport. The data are used by a variety of federal, provincial and industrial clients for flood flow forecasting and reservoir regulations planning and operation of hydro-electric facilities, irrigation, navigation, industrial and municipal works, as a basis for determining apportionment between provinces and among licensees, and to meet various requirements of international obligations and federal-provincial agreements.

The government pays the full costs of "federal" stations and one half the cost of "federal-provincial" stations. The provinces pay the costs of "provincial" stations.

"Federal" stations include:

(a) those that are required under statutory obligations or support programs of various federal agencies which include specific federal works, studies or investigations, research projects, navigational requirements and management responsibilities;

(b) those that monitor waters flowing across or which form part of provincial or territorial boundaries and where federal responsibility has been established by agreement or is justified by an inter-jurisdictional concern;

(c) those on streams crossing or forming part of the international boundary for which there are federal responsibilities arising from treaties, agreements, studies or ITC orders; and,

(d) those required to define a national inventory of surface waters including information on trends in major drainage basins, total surface water resources and significant discharge to the oceans.

"Federal-provincial" stations include:

(a) those where both governments have stated an interest in the need for the information;

(b) those where joint responsibility is established under federal-provincial agreement; and,

(c) those that provide an assessment of the quantity of water available in distinct hydrologic zones within a province.

"Provincial" stations are those whose data are required in support of specific provincial projects, including municipal and non-governmental interests.

5.2 The Program

As of April 1982, the network included 3,074 stations, an increase of 235 since the program was formalized by federal-provincial agreements in 1975. Of this total, 1,182 were classified as federal stations, 871 were federal-provincial and 1,021 were of provincial interest only. Data from an additional 321 stations contributed by other agencies, located primarily in Québec, Ontario and Alberta, brought the total network to 3,395 reporting stations. Sediment data were obtained from only 104 stations of the network.[1]

Total program costs in 1982-83 were $18,870,700 to which the provinces contributed $4,634,200, leaving a net federal cost of $14,236,500. Canada paid an additional $665,400 to Québec for data obtained from its network bringing the total federal cost to $14,901,900.

A total of some 356 person-years of employment were used for the water survey in 1982-83, a slight decrease since 1975 even though the network had grown by 8% during the period.

5.3 Previous Evaluations

An independent evaluation of the program made in 1977 by Acres Consulting Services Ltd., indicated a benefit/cost ratio of eight to one (8:1).

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[1] Environment Canada, 1984. Water quantity surveys federal-provincial cost-sharing agreements. Annual Report 1982-83.

An internal evaluation was completed in 1980.[1] The study identified a number of deficiencies, most of which have been addressed and largely overcome. Among the more important issues and responses were the following:

(a) The governments' restraint program had reduced the ability to respond to requests from provinces for the addition of new stations to the network as provided for under terms of formal federal-provincial agreements. The issue was not so much one of funding since half or all funds were to be contributed by the provinces making the requests. The problem was that of obtaining manpower to operate the stations. Person-years dedicated to the water quantity program has decreased from 363 to 346 between 1975-76 and 1980-81 while the number of gauging stations had increased by 7%. Manpower had been stretched to the extent that new stations could only be added with further reduction in ability to analyze data, evaluate and plan the network. The situation has been partly rectified by the addition of some 26 person-years to the program.

(b) The Water Survey of Canada had been slow in employing new technologies for collecting and processing data from remote locations. Approval was received in 1982-83 for the addition of 350 data collection platforms over a five-year period. These stations transmit data through satellites to a receiving station in the United States and thence by ground lines.

The program still requires improvement to reduce costs and the loss of data through ground line transmission

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[1] Environment Canada, 1980. An evaluation of the hydrometric surveys component EMS water management data program, No. 51. Project Ref. No. DOE/EMS.4.79/80.

from the receiving station. This could be overcome with the establishment of three Canadian receiving stations. The Department is preparing proposals to establish such stations for the joint use of water survey and meteorological stations.

(c) The Department was criticized for not assuming a more assertive role in analyzing and interpreting data, confining itself to collection, processing and archiving functions. In response, mini-computers have been obtained for headquarters and regional offices to allow for some preliminary data analysis, interpretation and network evaluation.

5.4 Outstanding Issues

5.4.1 Level and Type of Data Services

Clients are constantly seeking data on a faster near-real-time basis. Use of satellites for transmission of data from automated data collection platforms only whets the appetite of the users for flood forecasting, reservoir regulation, irrigation operations, navigation controls, and so forth. To meet the demand, the Water Survey of Canada will have to develop a more comprehensive publication and distribution system for hydrological information.

At the same time, demands are growing for information on parameters in addition to streamflow, levels and sediments. Data on water quality, temperature, hydraulics of flow, as well as snow and ice are becoming increasingly important as inputs to water resource management models. More comprehensive data on ice conditions is sought for predicting spring break-up and the formation of ice jams. Atmospheric data on rainfall, termperature and humidities is also sought from remote locations.

> IT IS RECOMMENDED that the Water Survey of Canada, in cooperation with the Atmospheric Environment, continue to pursue a comprehensive network of automated data collection platforms in inaccessible areas of Canada together with the development of a satellite/computer based data communication and distribution system and with the establishment of satellite data receiving stations in Canada. To meet demands, new parameters, particularly water temperature, should be added at selected stations.

Providing data on a near-real-time basis and on a larger number of factors will increase costs. At the present time, Water Survey data are supplied on request at no charge. This is not consistent with meteorological data available from the Atmospheric Environment Service of the same department where service charges sometimes apply. Environment Canada's services should adopt common recovery policies to help defray rising costs and to help ensure that demands for data are in response to real needs.

> IT IS RECOMMENDED that Environment Canada review the data distribution systems of its various services with the intention of applying a cost-recovery policy for data supplied to clients who are not party to federal-provincial data gathering agreements.

5.4.2 Analytical and Interpretive Tools

The advent of sophisticated computer models and analysis techniques offer important opportunities for water managers. Opportunities for improved accuracy and efficiency lie in the intensive analysis of existing data to achieve optimum network design, to apply data from monitored watersheds to those that are not, and to improve operational procedures.

While it is now possible to identify redundancies in existing networks, the ability to predetermine the best mix and location of stations is just emerging.

> IT IS RECOMMENDED that the Inland Waters Directorate receive increased resources to strengthen the statistical analysis and modelling capability of its new Hydrology Division with a five-year objective of a net increase in network efficiency.

5.4.3 Sediment Survey

The Department has only a very small complement of 11 person-years employed on sediment survey and analysis. Basic data are now collected from over 100 sites but too little expertise is available for analyzing and interpreting data, or planning an effective network. The majority of sampling stations for routine sediment data have been established for specific project needs of clients. Fluvial morphological surveys to assess the dynamics of rivers, lakes and reservoirs as a result of erosion and sedimentation have been carried out on an ad hoc basis at the request of other agencies such as the Prairie Provinces Water Board.

Other federal and provincial agencies conduct sediment studies related to their particular interests such as determining the impacts of man's activities on fish habitat, tracing pathways of toxic substances, estimating the potential impact of sediment on proposed reservoirs, and determining dredging requirements for shipping channels. There appear to be opportunities for increasing the effectiveness of these various sediment related programs through improved coordination. For example, a well designed sediment survey by the Water Survey of Canada could respond to the needs of those interested in tracing the movements of toxic substances.

Morphological studies of rivers used for commercial shipping could identify ways to change sedimentation patterns and the need for expensive dredging. There seems to be a missing catalyst, however, in that there is no particular centre of stream morphology expertise within the federal government.

> IT IS RECOMMENDED that Environment Canada employ the Interdepartmental Committee on Water to undertake a comprehensive review of sediment related issues of interest to federal agencies and examine the potential for improving the effectiveness and efficiency of programs through mutual support or integration into a centre of excellence.

5.4.4 Snow and Ice Monitoring

In 1980, a basic glacier volume-change monitoring program in Alberta and British Columbia was discontinued to allow reallocation of resources to programs of higher priority. Yet the advance or retreat of glaciers is reportedly sensitive to very small changes in average temperatures and monitoring such changes could provide early warnings of climatic changes associated with atmospheric carbon dioxide build-up.

The Inland Waters Directorate has also found it necessary to reduce its involvement in monitoring the water equivalent of winter snow accumulations, restricting itself to those areas where federal-provincial flood forecasting agreements are in place.

Recent advances in satellite imagery, its interpretation, and automatic data telemetry systems offer intriguing prospects to study glacier dynamics and the water content of snow accumulation with the expenditure of little manpower.

Since both glacial ice and snow accumulated over the winter period are essentially reservoirs of water, data on their condition is extremely valuable to water resource managers in virtually all areas of water use.

> IT IS RECOMMENDED that the Inland Waters Directorate be given the responsibility to develop remote sensing procedures and automatic data acquisition instrumentation with the aim of applying the results of glacier volume-change and snow condition monitoring programs to meet the requirements of water resource managers.

5.4.5 Information Services

Users of water resources and related data often are unaware of all the series of information that are available, where they may be obtained and at what cost.

> IT IS RECOMMENDED that Environment Canada provide a coordinated information service and publish a directory of water related data and sources thereof.

5.5 Challenges for the Future

According to recent observations, Canada may be moving from a sustained period of fairly predictable seasonal climatic conditions to a period of more dramatic swings in weather systems. At the same time, speculation is growing that major change in climate may be expected over the next few decades as a consequence of increasing concentrations of atmospheric carbon dioxide and the "greenhouse" effect it may initiate.

These changes may be expected to cause an increase in the number of severe flood events on the one hand an the occurrence of more frequent and extended periods of drought on

the other. Demands for flood hazard reduction measures like forecasting services and storage reservoirs may be expected to increase. Requirements for irrigation will also rise. These increasing pressures will be in addition to the usual growing demands for water for hydroelectric facilities, industrial and municipal services.

Demands may well increase in some basins to the extent that they will surpass supplies and lead to a growing number of interbasin transfers.

Wise response to the anticipated pressures on water supplies can only evolve from a sound knowledge base of availability gathered over an extended period of time to ensure an understanding of the extremes that may occur.

Thirty years of continuous records are often required to yield adequate data for planning purposes; but even that may not be enough. For example, there has been no flooding in the Calgary area on the Bow River in the last 52 years, but there were seven significant floods there in the preceding 35 years.

As Canada's population and economic development continue to grow, possibly confronted with greater variability of weather systems combined with a gradual overall change in climatic conditions, the needs for knowledge of water supplies can only be expected to increase. The Water Survey of Canada fills a significant portion of the need, but improvements will be required as water management becomes more intensive in response to increasing demands and diminishing "surpluses" with which to meet them. Some of the improvements needed have been outlined above.

The Water Survey of Canada fits the jurisdictional setting of mixed responsibilities for water management and provides the important elements of standardization of sampling methods, minimized duplication of sampling by different agencies, and a common data storage and distribution system. These factors all contribute to cost effectiveness, and the federal-provincial cost-sharing arrangements reasonably reflect user values for the data.

It is essential to maintain a single national agency for basic water resource data collection, storage and dissemination. The single agency concept ensures the integrity of data, enables the maximization of useful information contained in the data, and inhibits duplication of effort.

6. WATER MANAGEMENT DATA - QUALITY

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6.1 Introduction

The Water Quality Branch of Environment Canada provides ambient water quality data and interpretive information on international, interprovincial and other waters of significant national interest. It operates a monitoring program through its regional offices by collecting samples from some 670 stations across Canada, analyzing these samples in the national laboratory and entering the data in the computerized National Water Quality Data Bank (NAQUADAT). These data are used to define the health of Canada's water resources, delineate areas of pollution, detect emerging pollution problems, identify transboundary movement of pollutants, provide baseline water quality data for environmental assessments of proposed developments, formulate regulations, develop water quality criteria and objectives, develop water pollution abatement programs and evaluate the effectiveness of such abatement programs, and meet the federal government's obligations under applicable legislation, federal-provincial and international agreements and treaties.

Surface waters represent the major class of samples analyzed in these laboratories but other aquatic substrates such as precipitation, sediment and aquatic organisms are also analyzed. Approximately 50,000 samples are analyzed annually.

In addition to monitoring water quality and making this information available, the Water Quality Branch recommends water quality objectives for Canada. A water quality objective is expressed either as a concentration of a constituent or as a description of the body of water.

The initial water quality monitoring program of the federal government, starting in the 1930's, was industry-oriented, measuring natural chemistry parameters and specific conductance, suspended solids and turbidity. The International Hydrological Decade (1964-74) led many countries to monitor water quality as part of a global undertaking. Canada set up a national monitoring network of approximately 1,000 stations with regional analysis laboratories in Calgary, Moncton and Ottawa. Part of this network was established in direct response to International Joint Commission studies of the Great Lakes, St. Lawrence, St. Croix, Red and Rainy Rivers as well as the Garrison Diversion Project. Other components were installed as part of federal-provincial river basin planning exercises.

Following the A-Base review of Environment Canada in the mid-1970's, the definition of significant national concern seemed to change. The national water quality network was required to beat a hasty retreat to the borders, primarily the Canada-U.S. border, where Canada has both explicit jurisdiction and commitments to the IJC. Other stations were retained on interprovincial waters where Canada had made monitoring commitments, such as to the Prairie Provinces Water Board.

In 1982, the government reappraised its role in light of significant water quality problems that where showing up. It agreed to the establishment of a new national water quality network based on federal-provincial cost-sharing agreements. Forty new person-years and an annual budget of $2 million were allocated, with some cost recovery from provinces entering agreements. Areas of significant national concern included monitoring for the impacts of acid rain and toxic substances.

6.2 The National Water Quality Assessment Policy

The objectives of the new water quality assessment program are to:

(1) provide sceintific and technical information and advice to governments, private agencies and the public; and,
(2) detect emerging water quality problems and to evaluate issues from regional and national points of view.

More specifically, water quality monitoring objectives are to:

(a) determine changes and long-term trends in water quality;
(b) detect emerging quality problems;
(c) determine the effectiveness of regulatory measures; and,
(d) assess the need for special investigations.

The strategy adopted is to negotiate federal-provincial monitoring and cost-sharing agreements. Networks are to be based on river basin requirements. Cost-sharing arrangements, similar to those of the Water Survey of Canada, are to be determined on the basis of federal and provincial interest in each station. Federal interests relate to international and interprovincial waters, the North, federal lands, and the pervasive problems of toxic chemicals, long-range transport of air pollutants, and nutrient controls.

Issues of priority concern addressed by the national water quality assessment program include the ambient quality of the Great Lakes and other international waters across the country. Along with routine assessment programs on behalf of the government, special studies are carried out to advise the International Joint Commission. The identification of toxic substances and determination of their concentrations, through sophisticated laboratory techniques, has become a major preoccupation of the program.

On interprovincial, provincial-territorial, and provincial waters priority issues include determination of the effects of industrial and agricultural development and the insidious impacts of acid rain.

To ensure consistency and comparability of results, all provincial laboratories that may be employed in the program will be coordinated with Environment Canada's quality controls.

6.3 The New National Monitoring Program

The new national water quality assessment program, to be developed through federal-provincial agreements, will yield a national monitoring network integrating the needs of federal and provincial governments, and providing a National Water Quality Bank (NAQUADAT) containing comparable data obtained through sophisticated and standardized analytical techniques.

The only federal-provincial agreement in place to date is with Quebec. Negotiations are well advanced, however, with Newfoundland, Alberta and British Columbia.

The determination of cost-sharing arrangements for individual stations is based on the interests of the two governments and on negotiation. In Québec, for example, the "federal" stations include networks on transboundary waters, along the St. Lawrence, in Nouveau Québec, and an acid rain network covering some 30 lakes. The majority of "federal-provincial" and "provincial" stations are on tributaries to the St. Lawrence. The "federal-provincial" stations include a 48 station toxic chemicals network. In total, there are 478 stations, 27.4% of which have been designated as "federal", 37.0% as "federal-provincial", and 35.6% as "provincial". The Province operates the majority of the network.

Vital to the success of water quality monitoring are sophisticated laboratory facilities with strict quality control of analysis procedures. Environment Canada operates a national laboratory at Burlington, Ontario and regional ones at Moncton, Longueil, Saskatoon and Vancouver. These facilities conduct analyses for time-sensitive parameters such as dissolved oxygen, pH and conductivity. The National Water Quality Laboratory at the Canada Centre for Inland Waters, Burlington, is being expanded to handle the complex and expensive analyses for toxic chemicals and dissolved metals on a national basis. Where provincial laboratories are to be used, the agreements will provide for quality control by Environment Canada.

6.4 Program Administration

Federal interests in network and sub-network design are determined through consultation among the services within Environment Canada and with other interested agencies such as Fisheries and Oceans.

New resource allocation to the federal-provincial water quality network began in 1983-84 with 6 person-years and $471,000. As the program develops to a full national network, a total of 40 person-years and an annual outlay of $2.05 million is expected to be required, of which about 68% would be recovered from participating governments. The network should be complete by 1986-87.

6.5 Comment

The adoption of the federal-provincial cost-sharing agreement approach for the water quality monitoring program is another example of cooperative arrangements that enhance coordination, improve data compatibility and promote efficient use of available resources.

The objectives of the monitoring program can only be met by maintaining the network on a long-term continuing basis. This requires long-term commitment of funds, something governments prefer to avoid so that resources may be reallocated in response to changing priorities. Acceptance of the formal agreement process will help to ensure a continuing commitment of resources, but does not guarantee it. To maintain support, it is essential that as experience with the network develops, it be refined through analyses of station location, parameters monitored, sampling frequency and sampling methods. The possible advantages of combining some water quality sampling needs with the water quantity monitoring network need to be explored in greater depth than seems to have been the case to date. Suspended sediment quality analysis may become more meaningful if coordinated with the monitoring of river morphology augmented by sediment core analyses for contaminants. Several quality factors such as pH and conductivity may be amenable to automatic sensing and data transmission from the Water Survey of Canada's expanding network of data collection platforms.

> IT IS RECOMMENDED that the design of national networks for water quality and water quantity monitoring be thoroughly examined for opportunities of mutual support and cost economies.

In spite of the fact that the federal government has full responsibility for water management in Yukon and the Northwest Territories, the water quality monitoring network has yet to be expanded into those regions. The Department of Indian Affairs and Northern Development does, however, maintain a water quality surveillance program of industrial and municipal facilities. While not of highest priority, at least a skeletal component of the network is needed to follow up on early indications of acid rain and

other airborne pollutants, to monitor for potential influences of tar sands operations in Alberta, as well as to maintain long-term surveillance of streams below abandoned mine sites.

The national water quality monitoring network is, or will become, a vital intelligence component in Canada's water and environmental quality management systems. Its data, in combination with that from the Water Survey of Canada, will provide the basis for intelligent water development and regulatory planning.

The final comment of the previous chapter applies to the national water quality monitoring network as well. The combining of federal, provincial and industrial interests in a cost-shared and work-shared program is the most efficient approach in the Canadian context.

> IT IS RECOMMENDED that the federal government maintain a long-term commitment to the national water quality assessment program.

7. PLANNING

7. PLANNING

7.1 Introduction

The concept of water resources planning, comprehensive planning in particular, was introduced as a federal policy in the Canada Water Act (1970). Prior to that time, federal involvement with the provinces had been limited to the involvement in engineering, benefit-cost analysis and financial contributions to flood control projects under the Canada Water Conservation Assistance Act (1953). The multi-purpose planning and management concept gained popularity with the growing awareness that pollution from industrial and municipal sources was disrupting or making other uses more expensive in eastern Canada, that Canada was experiencing a period of rapid growth with new and competing demands on water resources, and that actual or perceived shortages in western Canada and the United States posed critical problems of conservation and apportionment to sustain economic and social development.

The river basin planning program implemented under the Canada Water Act has been described in detail by Brulé, Quinn, Weibe and Mitchell (1981). Its main features are outlined here to provide the background for comment and recommendation, and one specific planning strategy, the flood damage reduction program, is described in some detail in Chapter 9.

7.2 Objective

The basic objective of Environment Canada's water planning policy is embodied in the preamble of the Canada Water Act:

> "...the Parliament of Canada is desirous ... that comprehensive programs be undertaken ... in cooperation with the provincial governments ... in relation to water resources for research and planning ... and for their conservation, development and utilization to ensure their optimum use for the benefit of all Canadians."

7.3 Strategy

Section 4 of the Act provides authority to the responsible Minister to enter into agreements with provinces "to formulate comprehensive water resource management plans" where there is a "significant national interest".

The operational strategy involves federal-provincial consultations that lead to the identification of candidate river basins for joint comprehensive planning, or single-issue planning respecting problems of federal and provincial concern. Formal agreements define the nature of planning studies and provide for 50:50 cost-sharing.

Cooperation of federal and provincial agencies most initmately concerned with water management is achieved through appointment of their representatives to the supervisory board established to management the program and the apportionment of some of the funding to them to provide for studies of special interest to these agencies.

Canada Water Act planning agreements are restricted almost entirely to interjurisdictional river basins, to rivers important to salmon, or to river systems in the territories -- that is, water courses where the federal government has some jurisdiction over water. There have been minor exceptions, but the guiding rule seems to be one of concentrating on waters with federal responsibilities.

7.4 The Program

Initially, the federal government was a strong proponent of comprehensive multi-purpose planning exercises. Studies of the Qu'Appelle, Okanagan, Souris, Saint John and Shubenacadie-Stewiacke basins are examples. It became evident at an early date, however, that most provinces preferred concentrating planning activities on specific issues, or opted to concentrate on detailed planning at the local level. The federal policy has been flexible enough to respond to the single issue approach, the most outstanding initiative being its flood hazard reduction program introduced in 1975. (This program is discussed in some detail in Chapter 9.) Detailed planning at the local level, as exemplified by some of the programs of Ontario's Conservation Authorities, has usually been perceived as outside federal jurisdiction by both the provinces and the federal government.

In addition to multiple purpose planning, several agreements have been restricted to water quality aspects. These have included Lake Winnipeg, the Ottawa River and the St. Lawrence River. Several studies have concentrated on flow regulation. Studies of the Ottawa River and Montreal region pertained to flow regulation for flood control, hydroelectric power generation, navigation, recreation and water quality needs.

Ecological problems were the centrepiece of studies of the Peace-Athabasca Delta. The studies were designed to find ways to mitigate the impact of a new hydroelectric dam upstream. Ecological studies of north shore tributaries of the St. Lawrence were conducted to facilitate impact assessments of future major development proposals.

Two joint studies have been directed at issues of individual cities. A study of the Waterford River flowing through St. John's, Newfoundland, was designed to examine the impact of urbanization on the watercourse and to prepare development criteria to protect it. In the Charlottetown area, a study of the local ground water aquifer potential to supply the city has been completed.

Implementation of planning study recommendations has occurred in several ways. In some cases, there has been formal implementation as was the case for the Qu'Appelle River. In this instance, the funding arrangements of several agencies were coordinated by the Department of Regional Economic Expansion. The implementation agreement for the Okanagan included CMHC loan funds for municipal sewage treatment and Canada Water Act contributions for improvements to flood control works. In some cases, no formal implementation agreements were signed, but arrangements were made to involve the funding programs of appropriate federal departments. This was the case with the Souris River Basin study.

In other instances, the majority of recommendations were more appropriate to entirely provincial implementation. This was apparently the situation with the Shubenacadie-Stewiacke Basin study and the water quality study of the St. Lawrence.

7.5 Comment

The shifting emphasis away from comprehensive river basin planning is indicated in Table 7.1. Of the Inland Waters Directorate's total resources of $100,290,000 and 1,033 person-years of employment, less than 1% was used for

river basin planning. These figures exclude the flood damage reduction program, which has become Environment Canada's major planning program. In 1983-84, for example, $9,323,000 and 31.5 person-years were dedicated to the flood damage reduction program.

Table 7.1

CANADA WATER ACT RIVER BASIN PLANNING
ENVIRONMENT CANADA EXPENDITURES

YEAR	$000	PERSON-YEARS
1979-80	1,812	32.0
1980-81	1,835	21.9
1981-82	1,374	21.8
1982-83	939	9.2
1983-84	1,062	8.8

The Inland Waters Directorate has been very conservative in its judgments as to what constitutes "significant national concern", the principal criterion on which federal participation in water resources planning programs is decided. With few exemptions, it has confined its involvement to situations where the federal government has a clear jurisdictional role respecting water. This is unfortunate. There are other federal roles in the national interest that require careful water planning and management. Regional economic development is one. Protecting public health is another.

While it is quite appropriate for a department with a resource management-type function not to become involved in water development projects that may receive federal

support in the regional development context, it is appropriate to be involved in planning for the optimum use of water for regional development. The purpose of the Canada Water Act provides for this role as does Environment Canada's definition of "significant national interest".

Why then has the Inland Waters Directorate not offered to assist Prince Edward Island in assessing the potential of its ground water aquifers to support economic development? Why has no program been offered to monitor the quality of the Island's ground water, already known to be contaminated in some locations by agricultural pesticides? The Prince Edward Island economy is virtually dependent on ground water. It is obviously in the national interest to determine the extent and capacities of the aquifers, their quality, and their susceptibility to pollution by salt water intrusion from below or pesticides from above.

Prince Edward Island's ground water is but one example of an area where there would be "significant national concern" albeit no federal jurisdiction with respect to the water itself. Other regions of Canada are similarly dependent on ground water, yet the Inland Waters Directorate has been reluctant to get involved, unless an aquifer happens to straddle a provincial boundary. This is a mistake, failing to fulfill a responsibility in an aspect of water management of "significant national interest".

> IT IS RECOMMENDED that the Inland Waters Directorate, Environment Canada, reassess its role respoecting water management for regional economic development, particularly in those regions dependent on ground water.-

IT IS FURTHER RECOMMENDED that the Inland Waters Directorate develop closer ties with the Department of Regional Industrial Expansion so that it may help identify and respond to water research, monitoring and planning needs in support of regional development policies and programs.

8. REGULATION

8. REGULATION

8.1 Introduction

The federal government plays advisory, operational, legislative and advocative roles respecting the regulation of water levels and flows, navigation, shipping, pollution and fish habitat. This brief chapter concentrates on the last two because they sometimes lead to federal-provincial and interdepartmental frictions. Some of the other regulatory roles must at least be mentioned, however, because of their considerable importance. They tend to be taken for granted because they operate smoothly, even though some of them stem from what were difficult interprovincial or international problems. A few examples of the federal roles in regulating water quantity are outlined in the following section.

8.2 Regulating Water Quantity

8.2.1 Federal-Provincial Arrangements

Environment Canada and PFRA sit on the Prairie Provinces Water Board. Environment Canada chairs the Board, provides 50% of its budget ($352,000 in 1983-84), and undertakes the streamflow and quality monitoring required by the Board in implementing the apportionment agreements. The Board undertakes specific investigations related to the apportionment agreement, and some of these are conducted by Environment Canada. Examples include a study of return flows from major irrigation systems and reservoir evaporation estimation models.

In 1983, Canada, Ontario and Quebec entered an Agreement Respecting Ottawa River Basin Regulations. Under this agreement, the Ottawa River is regulated, taking account of the interests of hydro-power production, flood protection, navigation, low water problems, recreation and water quality factors. Canada, through Environment Canada, provides a small secretariat, contributes to technical studies required and supplies 50% of the funding required.

Since 1919, Canada and Ontario have participated in the Lake of the Woods Control Board. Manitoba became a full partner in 1958. Established under the Lake of the Woods Control Board Act, the Board regulates the outflows of Lake of the Woods and Lac Seul to achieve conditions satisfactory to the various interests. A permanent engineering group/secretariat is maintained by the Inland Waters Directorate of Environment Canada. Canada pays one-third of the costs based on its interest in navigation, while the two provinces share the remainder in proportion to the developed hydroelectric power developed in each.

8.2.2 International Arrangements

For international waters, federal managers represent Canada on 12 Boards of Control reporting to the IJC on the supervision of Canada-U.S. agreements respecting the levels and flows of lakes and rivers. Environment Canada, Fisheries and Oceans, and Transport supply the required water monitoring data. The Boards of Control regulate the St. Lawrence, Niagara, St. Croix, Rainy River, Lake of the Woods, Souris, St. Mary-Milk, Osoyoos, and Columbia Rivers, and Lakes Superior, Kootenay and Champlain.

The IJC has also appointed a number of investigative-engineering boards to assist in responding to Canada-U.S. references respecting the regulation of boundary water flows and levels. Experts from Environment Canada serve on these Boards and perform investigative studies required. There are investigative-engineering boards examining quantitive and qualitative issues on the Souris and Red Rivers, Garrison Diversion, Lake Erie Regulation, Great Lakes Diversion and Consumption, Poplar River Quality and a Great Lakes Levels Advisory Board.

Several Canada-U.S. water regulation agreements are the substance of special treaties and do not fall under the aegis of the IJC. These include the Columbia River Treaty Permanent Engineering Board, Lake Memphremagog Board, and the Niagara Treaty Board. Again, Board membership and technical data are supplies by federal agencies, primarily Environment Canada.

Unfortunately, no separate estimates of financial and personnel resources committed to these international regulatory bodies are available, but they obviously amount to a substantial base load, particularly for the Inland Waters Directorate of Environment Canada. Their significance must not be forgotten when personnel and financial quotas are set each year.

8.3 Regulating Water Quality

8.3.1 Introduction

The federal government provides for the protection of water quality through both direct and indirect means. Indirect approaches include, among others, provisions of the Clean Air Act, Transportation of Dangerous Goods Act, Pest Control Products Act, and the Environmental Contaminants Act. Only the last two have been dealt with in this review.

The major shortcomings of the Environmental Contaminants Act are addressed in Chapters 2 and 13. Both Environment Canada and National Health and Welfare are aware of its deficiencies including the painfully slow implementation procedures that the Act requires. The urgency of revising the Act into a truly useful tool for protecting human health and the environment cannot be over-emphasized. The public assumes that the necessary regulatory tools are already in place. They are not. Revision of the Act should be one of the Government's top priorities.

The following discussion concentrates on fish habitat management for two reasons. First, it is the traditional jurisdictional basis for federal involvement with water pollution control at the local and national levels. Second, it has been the subject of difficult federal-provincial relations and interdepartmental frictions.

8.3.2 Fish Habitat Management

8.3.2.1 Introduction

Jurisdiction over fisheries has provided the federal government with its principal power over water pollution at the local or regional levels. The pertinent sections of the Fisheries Act were outlined in Chapter 2.

In 1983, the Department of Fisheries and Oceans published a discussion paper in which it outlined a proposed fish habitat management policy.[1] While the policy has not been finalized, it is not expected to be changed to any substantial degree. It applies to both the physical disruption and the chemical pollution of fish habitat.

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[1] Fisheries and Oceans, 1983. Toward a fish habitat management policy for the Department of Fisheries & Oceans, Ottawa.

8.3.2.2 <u>Objective</u>

The overall objectives proposed by Fisheries and Oceans are:

> "to conserve, restore and develop fish habitats to improve the production of Canada's fisheries resources for the benefit of present and future generations."

The sub-objectives are:

> "(a) to prevent damage to fish habitats supporting Canada's fisheries resources;
> to restore fish habitats in selected areas where economic or social benefits can be achieved through the fisheries resource; and,
> (c) to develop fish habitats in selected areas where the production of fisheries resources can be improved for the social and economic benefit of Canadians."

The basic principle behind the policy is that there will be no net loss of the productive capacity of those habitats that support Canada's fisheries resources.

8.3.2.3 <u>Strategies</u>

The objectives would be obtained through implementation of the following strategies:

(a) enforcing the Fisheries Act and incorporating habitat protection requirements in land and water use activities and projects;

(b) participation in cooperative resource planning to incorporate fish habitat priorities in air, land and water management;

(c) consultation with the public on major or controversial fish habitat issues and on the development of habitat policies and legislation;

(d) encouragement of community involvement in the conservation, restoration and development of fish habitat;

(e) restoration of the productive capacity of fish habitat, directly or in cooperation with others;

(f) investment to improve the natural productivity of habitats where economically feasible or socially desirable; and,

(g) scientific research on the conservation, restoration and development of fish habitats.

8.3.2.4 Strategy Implementation

Fisheries and Oceans face real difficulties in attempting to implement its new fish habitat management policy. First, the Fisheries Act, the principal legal tool for implementing the policy, is administered by the inland provinces, rather than Fisheries and Oceans. Second, Section 33 of that Act is administered by the Environmental Protection Service of Environment Canada. Fisheries and Oceans must either foster new levels of cooperation or find a way to retrieve the administration of their legislation.

Complicating the issue of administration of the Fisheries Act by provinces is the recent opinion of the Department of

Justice to the effect that the administration of sections of legislation providing ministerial discretion cannot be delegated. Section 31 of the Fisheries Act, dealing with the harmful alteration, disruption or destruction of fish habitat, is implemented primarily through discretionary powers; therefore, the inland provinces are administering federal legislation, a component of which they apparently are not empowered to deal with.

To date, the dilemma is unresolved. Fisheries and Oceans have long since withdrawn from day-to-day management of all fisheries in Ontario, Manitoba, Saskatchewan and Alberta and the fresh water fisheries of Quebec and British Columbia, excepting salmon. The federal government's traditional interests have been concentrated on the commercial fisheries and consequently their fresh water habitat interests were largely confined to the Great Lakes and Lake Winnipeg regions plus the waters used by the anadromous salmon. The Department must now find a way to influence decisions or developments intruding on fish habitats throughout the provinces. How can this be done?

8.3.2.5 Physical Disruption of Habitat

Fisheries and Oceans have adopted two approaches in coastal provinces where it still administers the Fisheries Act. In New Brunswick and Nova Scotia, where there are fairly sophisticated water use licensing systems, referral procedures have been developed through which Fisheries and Oceans personnel have the opportunity to contribute to the terms and conditions of licences. The approach appears to have produced reasonable results.

For both Newfoundland and coastal British Columbia, the Department has established its own approval system. Shoreline developers or water users must seek approval

from Fisheries and Oceans as well as obtaining the usual provincial permit or licence. A duel review system of this nature presents a high risk or both federal-provincial conflict and licence applicant frustration. There must be ways to build on the approaches used in the Maritimes to effect a single cooperative approval system.

Achievement of a federal-provincial approach may well require a modification of Fisheries and Oceans "no net loss" working principle for fish habitat management. Adoption of the principle is understandable. In the benefit-cost analysis of most projects, fish habitat would come out the loser. The fisheries manager sees a gradual dimunition of habitat quality and quantity and calls out for a halt. From a socio-economic point of view, however, a rigid application of the principle would not stand the test in many situations. The Department will have to develop a rather clear set of working strategies that will permit an element of flexibility in its approach to project proposal reviews.

> IT IS RECOMMENDED that Fisheries and Oceans seek the cooperation of the ICW and provincial departments in developing a working manual for implementation of its fish habitat policy.

If this approach proves successful, the obstacles to developing a simple, cooperatively administered water/fish habitat licensing system would be largely overcome.

8.3.2.6 Chemical Disruption of Habitat

Section 33 of the Fisheries Act covers the regulation of deposits of substances deleterious to fish. By inter-departmental agreement it is administered by the Environmental Protection Service (EPS) of Environment Canada. Through

Accords for the Protection and Enhancement of the Environment, the provinces, in turn, have undertaken to implement "national baseline requirements" for specific industrial groups and effluents. Thus, with respect to chemical pollutants, Fisheries and Oceans finds itself two steps removed from the effluent producers.

Until 1977, EPS concerned itself with the development of national effluent quality regulations that were issued under the Fisheries Act. At that time the government apparently became reluctant to issue additional regulations. EPS has continue to develop guidelines and codes of good industrial practice for use by the provinces in establishing pollution control requirements.

There have been instances, particularly in coastal British Columbia, where habitat managers of Fisheries and Oceans have felt that measures applied by the Province with the apparent concurrence of EPS were insufficient to protect important fish habitat areas. In these situations, Fisheries and Oceans has dealt directly with the industry involved. This type of situation should not be allowed to prevail. It creates too much uncertainty for industry.

It is understood that a new memorandum of understanding is being worked out between Fisheries and Oceans and Environment (EPS) to deal with the difficulties, but its contents are not available. The arrangements eventually agreed to should consider the following points.

First, the federal government must decide whether or not it is going to exert a regulatory role. Since 1977, there has been some doubt as to its intentions. Adding to this doubt is a new approach adopted by EPS a few years ago -- an advocacy role -- a role in which EPS would publicly draw attention to pollution issues and recommend measures

for dealing with them. Having merits in its own right, the advocacy approach implies a reduced federal regulatory program, or it seems to. It may be perceived as a thrusting of responsibilities onto the provinces -- making them the "bad guys" so to speak. "Bad" to industry for demanding expensive pollution control measures and "bad" to public for not being stringent enough. How can the situation be clarified, agency involvement simplified, the public satisfied, and fish habitat protected?

> IT IS RECOMMENDED that the federal government adopt the following principles respecting its involvement with fish habitat quality management and other aspects of water pollution control within its jurisdiction.
>
> 1. The government shall exercise its jurisdictional responsibilities respecting water pollution control.
>
> 2. The government shall maintain a single water pollution regulatory agency (EPS) to set and enforce effluent quality requirements.
>
> 3. EPS shall continue to establish minimum national baseline requirements for industrial effluents.
>
> 4. National minimum baseline requirements will be based on the advice of National Health & Welfare, Fisheries & Oceans, the Canadian Wildlife Service and other departments as appropriate, industry and the provinces.
>
> 5. Site-specific requirements for an individual industrial location shall be determined by Fisheries & Oceans in consultation with the province, so that they may be integrated with other socio-economic needs.
>
> 6. Environment Canada and Fisheries & Oceans shall endeavour to negotiate new "accords" with the provinces whereby provinces will undertake to administer federal requirements, with appropriate provisions for federal cost-sharing of this administration.

8.3.3 Federal-Provincial Cooperation

The desirability of combining the water pollution control strategies of the federal and provincial governments was recognized in the early '70's and eventually culminated as part of agreements known as Accords for the Protection and Enhancement of Environmental Quality. The intent was to provide a "one window" approach to the public so that industries would only have one bureaucracy to deal with.

The degree of success of the Accords would be described differently in different parts of the country. In some coastal provinces, frictions sill exist with provinces perceiving some national baseline standards to be closer to standards based on best available technology and beyond the requirements of fisheries protection. As already noted, however, Fisheries and Oceans have complained that in some situations, the requirements are not stringent enough. Probably all would agree that the Accords were a step in the right direction. How could they be improved?

When the Accords were first negotiated, the main issue was the implementation of the requirements of Section 33 of the Fisheries Act. Although the Accords provided for consultation on a broad range of environmental issues and anticipated additional agreements on various programs related to pollution control, sub-agreements have not evolved. The concentration has been on effluent quality regulation.

Since 1975, new issues have become prominent. Acid rain, toxic substances and the disposal of hazardous wastes are examples. The federal government has enacted the Environmental Contaminants Act providing for control of substances dangerous to human health or environmental quality. Fiscal restraint at both levels of government makes duplication of effort even less tolerable than before. New Accords are needed

involving more components of Environment Canada than EPS, and drawing on the expertise of National Health and Welfare to encompass this broader range of priority concerns and to stimulate the evolution of sub-agreements on priority issues. Sub-agreements should treat cost-sharing and work-sharing as well as the traditional "who does what".

It is understood that initial discussions have already begun with some provinces toward the negotiation of new Accords and this initiative is applauded.

> IT IS RECOMMENDED that Environment Canada pursue discussions with provinces to develop new agreements for cooperation on environmental management under which sub-agreements would be fostered on specific issues where work-sharing and cost-sharing would be emphasized.

9. FLOOD DAMAGE REDUCTION PROGRAM

9. FLOOD DAMAGE REDUCTION PROGRAM

9.1 Introduction

With few exceptions, Canada's population and economic investments have occurred along its major watercourses, often in flood-prone river valleys. In recent memory, major floods of disaster proportions have occurred in the lower Fraser Valley (1948), Winnipeg (1950), Toronto (1954), Montreal (1974 and 1976), the St. John River Valley (1973), and the Red River Valley (1979).

In addition to providing emergency flood fighting and evacuation assistance, the government has provided financial disaster relief to help restore flood-damaged homes and public facilities. Prior to 1970, financial assistance decisions were on an "ad hoc" basis. In 1970, a formal policy was adopted to assist provincial governments when costs exceed what a provincial government could reasonably be expected to pay. As per capita costs and damages increase to a provincial government, federal cost-sharing increases progressively as follows:

Provincial Costs Per Capita Eligible for Sharing	Federal Share
First dollar	0
Second and third dollars	50%
Fourth and fifth dollars	75%
Excess	90%

From 1970 to 1982, more than $80 million had been contributed by the federal government.

Besides disaster relief, the government has contributed to the costs of constructing structural works -- dykes and dams. Included have been the Winnipeg Floodway, Red River Community Dyking, the Shellmouth Reservoir, and the Assiniboine River Diversion among others. Under the Canada Water Conservation Assistance Act (1953), assistance under a fixed sharing formula was available for the construction of works for water conservation. Ontario made use of this Act to help finance flood control works in the metropolitan Toronto and Upper Thames regions. Some $70 million were contributed to these projects. The Fraser River Flood Control Agreement provides for a joint total expenditure of $120 million of which more than $100 million have been expended. The implementation agreements that followed the comprehensive river basin studies of the Qu'Appelle and Okanagan contained funds for flood control works. Some $9 million of federal contributions were committed to the Qu'Appelle and $1.5 million to the Okanagan.

As the population and industrial development of flood-prone areas continues to grow so does the potential for major disasters. Without land use regulations, dyking may actually encourage development in low lying areas and increase the risk of eventual disasters.

9.2 The Flood Damage Reduction Policy

In 1975, the Government adopted a more comprehensive approach with the objective of reducing future potential flood losses. Delivered through Environment Canada, the basic objective of the program is to discourage development on flood-prone lands and subsequent claims for disaster assistance and proposals to construct expansive structural flood control works. The strategy has been to enter 50:50 cost-sharing agreements with each province to:

(a) map and designate flood risk areas and floodways therein as appropriate;
(b) discourage new damage prone developments within the designated areas; and,
(c) examine all practical structural and non-structural alternatives and make selections based on effectiveness, cost, corollary benefits and environmental impact.

The General Agreements also provide that in those situations where floodways are designated within the designated flood risk areas, federal and provincial assistance programs may be applied outside the floodway but within the designated flood risk areas as long as any undertakings so constructed are adequately flood proofed.

Flood Risk Mapping Agreements that accompany the General Agreements provide a list of populated flood-prone areas for which flood risk areas and, if appropriate, floodways are to be mapped. The technical hydrologic, hydraulic survey and mapping specifications are set out. Provision is made for the Ministers to designate flood risk areas. Provisions are also included for the publication of maps and reports, their circulation to appropriate authorities and people and the initiation of a public information program.

A major precondition of the program was to gain the cooperation of the numerous federal agencies whose own programs could influence development in flood-prone areas. Agreements were effected through the Interdepartmental Committee on Water and confirmed by the Government. It was agreed that development assistance programs would not be available for undertakings within flood risk areas as designated through the federal-provincial Flood Damage Reduction Program. Major assistance programs under the

Regional Incentives Development Act and the National Housing Act, for example, are not available in the designated areas. The federal disaster financial assistance program will not apply to damages to new structures built in the designated areas. Numerous other federal agencies have agreed to take account of the commitments and constraints of the Flood Damage Reduction Program.

Where programs support land uses that are suitable to flood-prone areas, particularly those of the Department of Agriculture, they are not affected by the designation processes.

Where flood damage reduction measures seem to be required within the designated areas, the Flood Damage Reduction Program includes provisions for additional federal-provincial agreements respecting studies that may be required; flood forecasting and warning systems; flood proofing techniques; land use planning; works to control water levels and flows; and, the acquisition of property to reduce flood damage potential.

Provinces entering agreements under the Program commit themselves not to engage in or assist in new undertakings that would be vulnerable to damages in areas that become designated as flood risk areas. Provinces also agree to encourage land-use zoning appropriate to flood risk areas.

9.3 The FDR Program

By August 31, 1984, General Agreements Respecting Flood Damage Reduction and Flood Risk Mapping Agreements had been signed with all provinces except P.E.I., Alberta and

British Columbia. An equivalent memorandum of understanding had been signed by the Ministers of Environment Canada and Indian Affairs and Northern Development respecting the Northwest Territories but not for Yukon.

Total costs of the agreements amount to $71,754,000 of which $22,615,000 is for flood risk mapping, $6,130,000 for flood reduction studies, $2,000,000 for flood forecasting, and $41,009,000 for dykes, dams and other works. Provincial figures are shown in Table 9.1.

In the seven provinces and the Northwest Territories, all communities subject to significant flooding have been identified on schedules attached to the individual agreements and mapping, studies and works are in various stages of completion. Areas for which mapping has been completed and flood risk areas designated by the province are listed in Table 9.2.

Flood control works are in various stages of completion in areas in the vicinity of St. John, N.B.; Montreal, Québec and Richmond, Québec; several communities in the Red River Valley; and, near Hay River, NWT.

Some difficulties have been encountered in Ontario, Manitoba and Saskatchewan where residents of some communities have expressed concerns over the potential impact of flood risk designations on land values. In Ontario, the situation was further complicated by the decision to employ "event" floods, such as Hurricane Hazel, over rather large areas rather than a "once per 100 years" design flood. The latter problems have apparently been resolved by Ontario.

Table 9.1

FEDERAL-PROVINCIAL FLOOD DAMAGE REDUCTION AGREEMENTS

August 31, 1984

		Duration	Total Cost ($) **	Locations of Application of Agreement	Status
Newfoundland	General Agreement Respecting Flood Damage Reduction	12 years*	NA	NA	Signed: 5/81
	An Agreement Respecting Flood Risk Mapping	7 years*	1,470,000*	11*	Signed: 5/81
	An Agreement Respecting Studies for Flood Damage Reduction	5 years	480,000	3	Signed: 6/83
Nova Scotia	A General Agreement Respecting Flood Damage Reduction	16 years*	NA	NA	Signed: 6/78
	An Agreement Respecting Flood Risk Mapping	11 years*	1,030,000*	5*	Signed: 6/78
	An Agreement Respecting Studies for Flood Damage Reduction	11 years*	670,000*	2	Signed: 6/78
New Brunswick	General Agreement Respecting Flood Damage Reduction	15 years*	NA	NA	Signed: 3/76
	An Agreement Respecting Flood Risk Mapping	10 years*	2,000,000*	10*	Signed: 3/76
	An Agreement Respecting Studies for Flood Damage Reduction	10 years*	200,000	3	Signed: 3/76
	An Agreement on Flood Forecasting for the Saint John River Basin	10 years*	1,400,000*	NA	Signed: 8/77
	An Agreement on Flood Damage Reduction for Marsh Creek Watershed	6.5 years*	2,010,000	NA	Signed: 9/77
	An Agreement on Petitcodiac Sea Dykes	3 months	160,000	NA	Signed: 1/79
Quebec	An Agreement Respecting Flood Risk Mapping Applied to Flood Damage Reduction	16 years* (11 years mapping)*	6,000,000*	375*	Signed: 10/76
	An Agreement Respecting Dykes and Flow Regulation Works in the Montreal Region	7.5 years*	16,056,000	NA	Signed: 10/76
	An Agreement Respecting Flood Damage Reduction within the Limits of the City of Quebec	2 years	833,000	NA	Signed: 7/83
	An Agreement Respecting Flood Damage Reduction on the Mille Iles River	3.5 years	13,100,000	NA	Signed: 12/83
	An Agreement Respecting Flood Damage Reduction on the Saint-François River within the Limits of the Town of Richmond	3 years	4,350,000	NA	Signed: 5/84
Ontario	An Agreement Respecting Flood Risk Mapping and Other Flood Damage Reduction Measures in the Province of Ontario	12 years* (7 years mapping)*	1,200,000 (other) 8,000,000 (mapping)	***	Signed: 3/78
Manitoba	General Agreement Respecting Flood Damage Reduction	14 years*	NA	NA	Signed: 12/76
	An Agreement Respecting Flood Risk Mapping	8 years*	2,190,000*	45*	Signed: 12/76
	An Agreement Respecting Studies for Flood Damage Reduction	9 years*	310,000	14	Signed: 12/76
	An Agreement Respecting Flood Forecasting	5 years*	600,000	4	Signed: 3/81
	An Agreement Respecting the Upgrading of Ring Dykes in Certain Communities in the Red River Valley	3 years	4,500,000	8	Signed: 3/83
Saskatchewan	General Agreement Respecting Flood Damage Reduction Through Flood Area Management	10 years	NA	NA	Signed: 4/77
	An Agreement Respecting Flood Hazard Mapping and Studies	5 years	1,300,000 (mapping) 480,000 (studies)	30 14	Signed: 4/77
Yukon and N.W.T.	DOE/DIAND Memorandum of Understanding Respecting Flood Damage Reduction in the Territories	2 years	225,000	Hay River	Signed: 7/76
	DOE/DIAND Memorandum of Understanding Respecting Flood Damage Reduction in the Northwest Territories	10 years (5 years mapping)	400,000	7	Signed: 5/79
	An Agreement Respecting Flood Damage Reduction and Flood Risk Mapping (Canada/NWT)	10 years	NA	NA	Signed: 5/79

* Includes additional time or money or alteration in the locations for application of the agreement since original agreement signed.

** These costs are to be shared equally by the federal and provincial governments except for:
- a) federal: 33 1/3%, provincial/local: 66 2/3% - An Agreement on Flood Damage Reduction for Marsh Creek
- b) federal: 45%, provincial/local: 55% - An Agreement Respecting Dykes and Flow Regulation Works in the Montreal Region / An Agreement Respecting the Upgrading of Ring Dykes in Certain Communities in the Red River Valley / An Agreement Respecting Flood Damage Reduction within the limits of the City of Quebec / 'Other...Measures' part of An Agreement Respecting Flood Risk Mapping and Other Flood Damage Reduction Measures in the Province of Ontario / An Agreement Respecting Flood Damage Reduction on the Mille Iles River / An Agreement Respecting Flood Damage Reduction on the Saint-François River within the Limits of the Town of Richmond.
- c) Yukon and N.W.T. costs shared equally by DOE and DIAND

*** Agreement applied to flood vulnerable sections of
- a) streams, rivers and Great Lakes shorelines under the jurisdiction of 39 Conservation Authorities
- b) 20 river systems not under the jurisdiction of Conservation Authorities

Table 9.2

DESIGNATIONS TO DATE UNDER THE FLOOD DAMAGE REDUCTION PROGRAM

LOCATION	NUMBER OF COMMUNITIES MAPPED	NUMBER OF PUBLIC INFO. MAPS	POPULATION[1]	DATE OF DESIGNATION
NEWFOUNDLAND				
Stephenville*	2	1	9 000	June 84
1 designation	2	1	9 000	
NOVA SCOTIA				
East River*	5	1	16 900	Feb. 84
Sackville River*	3	1	7 100	Feb. 84
2 designations	8	2	24 000	
NEW BRUNSWICK				
Fredericton*	10	1	65 000	Feb. 80
Perth/Andover	2	1	1 900	Feb. 80
Oromocto to Lower Jemseg*	16	1	15 000	Mar. 81
Lower Fredericton to Lincoln*	3	1	3 000	Feb. 82
Sussex*	15	1	5 000	Sept. 82
Keswick*	5	1	1 100	Mar. 83
6 designations	51	6	91 000	
QUEBEC				
Montréal Region*	38	22	1 940 000	May 78
Chaudière Basin*	19	8	50 000	Mar. 79
Gatineau/Ottawa Rivers*	23	15	283 000	Oct. 79
Upper Richelieu River*	21	11	80 000	Apr. 80
du Gouffre*	4	2	9 000	Apr. 80
Lower Richelieu River*	21	10	125 000	Nov. 81
Rivière Assomption*	12	4	94 000	May 82
Rivière Saint-François*	14	6	170 000	Oct. 82
Rivière Yamaska*	19	12	64 000	June 83
Rivière Bécancour*	4	2	14 000	May 84
Rivière Nicolet Basin*	10	3	73 000	May 84
Trois-Rivières-Ouest	1	5	13 000	Aug. 84
12 designations	186	100	2 915 000	
ONTARIO				
White River	1	1	1 000	Aug. 82
Toronto*	24	8	3 000 000	Dec. 82
Sturgeon River/Lake Nipissing/ French River*	9	5	63 000	Mar. 83
Kaministiquia River*	2	1	39 000	Aug. 83
4 designations	36	15	3 103 000	
MANITOBA				
Melita	1	1	1 200	Dec. 79
Wawanesa	1	1	500	Dec. 79
Winnipeg	1	1	565 000	Feb. 80
Souris	1	1	1 750	Oct. 80
Elie	1	1	450	Nov. 80
Brandon	1	1	36 250	Mar. 82
La Salle	1	1	350	Nov. 82
Sanford	1	1	400	Nov. 82
Starbuck	1	1	225	Nov. 82
Swan River	1	1	3 800	May 83
Dauphin	1	1	9 000	Feb. 84
Carman	1	1	2 400	June 84
Lorette	1	1	1 100	Sept. 84
13 designations	13	13	622 425	
SASKATCHEWAN				
Estevan	1	1	9 200	Aug. 80
Oxbow	1	1	1 200	Aug. 80
Roche Percée	1	1	150	Aug. 80
Moose Jaw	1	1	34 000	Oct. 81
4 designations	4	4	44 550	
NORTHWEST TERRITORIES				
Hay River*	2	1	2 900	May 84
1 designation	2	1	2 900	
43 designations	302	142	6 811 875	

* These designations are on a regional or river basin basis and cover a number of municipalities or parts of municipalities.

1. Figures are approximate and based on 1981 Census data.

Community concerns seem to have been resolved in Manitoba and Saskatchewan. The latter is renegotiating its agreement, allowed to lapse while it established a new Water Corporation and reviewed its water management policies.

It is probable that local problems could have been minimized had communities been fully involved and informed about the Flood Damage Reduction Program while it was still in the proposal stage. While this aspect had been left rightly to the provinces, they themselves had not been involved with the Program until it had become a firm federal policy. Because of unique locational problems, it would be desirable to add more flexibility to accommodate local special situations so that undue land value depreciation will not occur. This may require additional flood control works.

No agreement exists with Prince Edward Island since both governments were of the opinion that the program was not necessary there.

Agreements have yet to be entered into with Alberta and British Columbia, primarily for technical reasons, or so it would appear. There is some concern that if these two provinces do not enter the program shortly, an inequitable situation will result with the federal disaster relief and other programs still applicable throughout those provinces while being restricted in the other seven provinces. Both Alberta and British Columbia have a high potential for flood losses. In British Columbia, the problem is particularly acute because of the location of communities in river valley and delta settings. In Alberta, the rapid development of low lying areas in the Bow River Valley in the Calgary area is creating the potential for heavy losses. Both provinces have mapped many flood-prone areas on their own, but much more needs to be done.

Should negotiations not reach fruition within a reasonable time, it may become necessary for the federal government to initiate its own flood risk mapping program in the two provinces to meet at least part of its original objective of reducing disaster-assistance claims and to ensure equitable treatment across Canada.

The Flood Damage Reduction Program began during the 1976-77 fiscal year and is expected to be completed in the early 1990's. Assuming the entry of Alberta, British Columbia, Yukon and Indian Reserves into the Flood Damage Reduction Program, the total costs of mapping, studies and flood forecasting is expected to reach $32,800,000 in current dollars. The federal share will be half of that amount. While a full evaluation of the program is pending, the approach offers great promise, particularly if it is carried through on the provincial and municipal levels to include land use restrictions in the designated flood risk areas. In addition to lessening the rate of flood damage increase, government relief and the necessity to invest in more expensive control works, the program would slow the rate of conversion of prime valley agricultural land to urban development. The Flood Damage Reduction Program provides one example of a government program that, while reactive to a bad situation, is forward-looking in attempting to guide future development to more appropriate areas, reducing potential losses and keeping land in more appropriate uses.

10. REGIONAL WATER DEVELOPMENT

10. REGIONAL WATER DEVELOPMENT

10.1 Introduction

With the exception of navigational facilities such as the St. Lawrence Seaway, and hydroelectric facilities on federal lands, the federal government rarely becomes directly involved in the development and operation of water resources on a regional basis. Its roles are usually confined to monitoring, research and planning in cooperation with provinces as precursors to development or in support of international or interprovincial agreements to regulate developments. Its program implementation roles have normally been confined to financial assistance for such things as dyking in high risk/high value areas like the lower Fraser River valley, or for pollution control programs such as that on the lower Great Lakes.

An exception to these traditional roles is found with the Prairie Farm Rehabilitation Administration (PFRA). Established by legislation in 1935 to counter the effects of the severe drought of the 1930's on the southern prairies, PFRA continues 50 years later as an active developer and operator of local and regional water supply systems for farm and community use.

10.2 Prairie Farm Rehabilitation Administration

10.2.1 Objective

The objective of PFRA, as defined in its enabling legislation, is to secure rehabilitation of drought and soil drifting areas and promote systems of farm practice, tree culture, water supply, land utilization and land settlement that will accord greater economic security.

10.2.2 Water Program

PFRA offers a variety of water development programs on the southern prairies ranging from the provision of small water sources on individual farms through systems designed to meet the needs of small groups of farms, to large scale systems to irrigate substantial districts and provide secure municipal water supplies. PFRA also provides an engineering and planning service to assist the provinces in developing long range water supply and drought proofing programs.

At the farm level, PFRA offers free engineering assistance in selecting, surveying, designing and developing water sources for livestock watering, irrigation and domestic water supplies. Dugouts, small dams, wells and irrigation systems are included in this program. Engineering services are provided free of cost while financial contributions are provided for source development and irrigation works. Maximum financial contributions per project range up to about $2,500.

For groups of five or more farmers or ranchers and for small communities of less than 300 people, PFRA will provide all engineering services and contribute 50 percent of construction costs for surface or ground water source development and distribution systems. The community water supply component of this program does not apply in Alberta where the Province elected to develop its own systems.

Subsidiary to the DREE General Development Agreements between provinces and the federal government, both Saskatchewan and Manitoba entered agreements on water development and flood proofing, in 1979 and 1980 respectively. These agreements provided for development of strategies to improve the effectiveness of water management, analyses of supply and demand for water, drought sensitivity analyses, and the provision of water supplies and delivery systems.

Drought sensitivity models were developed for both provinces allowing analyses of the impacts of drought periods and the estimated effects of water development alternatives. Investigations of the sizes and production capabilities of ground aquifers were completed. The feasibility of several irrigation schemes was investigated. Water supply systems were improved or constructed for a number of communities in each province. Structural flood control measures, fore-casting and warning systems for the Souris River were incorporated in the agreement with Saskatchewan.

The total cost of the agreement with Saskatchewan was $15.25 million shared as follows: PFRA - $7.4 million; Environment Canada - $0.5 million; Saskatchewan - $7.35 million. Of the total, $10.3 million was provided for water supply systems, equally cost-shared, with Saskatchewan adding the land required for developments and PFRA adding the engineering and administration of contracts.

The Manitoba agreement provided for $8.95 million with PFRA contributing $5.35 million and Manitoba $3.60 million.

PFRA's involvement in flood control work includes responsibility for the operation and maintenance of about 160 kilometres of dykes along the Assiniboine River from Portage la Prairie to Winnipeg.

With respect to irrigation, PFRA began constructing dams in southwestern Saskatchewan in 1935. The system now includes 26 dams, 23 of which are still operated by PFRA. The system serves some 19 120 hectares of land owned by PFRA, the Province and individuals. Forage crops are grown for live-stock in the dryland farming area. The system also provides municipal water for Swift Current and three other towns.

The South Saskatchewan River Project was designed and constructed by PFRA. Original plans called for some 222 500 hectares to be irrigated. Only about 14 160 hectares have received irrigation to date. The Gardiner and Summit dams are operated by PFRA at the expense of the Province.

Beginning about 1910, Canada developed a number of reservoirs and aqueducts for irrigation in the St. Mary and Bow River Valleys. Under terms of a 1973 agreement, Alberta has assumed ownership of the works and PFRA undertook to rehabilitate them. Rehabilitation is expected to be completed in 1988 at a cost in excess of $36 million.

Finally, PFRA, under terms of agreements with Alberta, Saskatchewan and Manitoba, has been involved in a substantial program to provide water and sewerage works for communities other than the major cities. These programs are outlined in some detail in the chapter on "Municipal Sewage and Water Facilities".

10.2.3 Summary

As the above outline demonstrates, PFRA is intimately involved in water resource development on the southern prairies from the smallest dugout or well on an individual farm to water and sewerage systems for hamlets, towns and small cities, to the operation of flood control works and the construction and operation of regional irrigation reservoirs and distribution systems. PFRA's technical expertise includes specializations in dam design and construction, flood forecasting, flood control works, satellite imagery interpretations, and economic planning, among others.

PFRA maintains a staff complement of close to 900 person-years. Its 1984-85 gross budget is approximately $56 million. About $14 million is used for PFRA's community pasture program, tree nursery operations and demonstration farm, leaving some $42 million for water related projects. The following table (10.1), taken from the latest available report from PFRA, lists the agency's expenditures and revenues.

10.2.4 Comment

(a) The PFRA Role

The severe drought of the '30's that spawned PFRA has long since passed. From time to time proposals to wind it up have been discussed. The periodic recurrence of severe drought years like 1984, the high regard accorded PFRA by farming and ranching communities, and the interests of ministers have sustained it.

PFRA has developed a unique niche as a federal agency. It sees itself, and seems to be seen, as a water developer-operator working directly with farmers and the three provinces to meet local and provincial needs within the provincial jurisdictional domain. It exhibits a refreshingly strong client orientation, providing services to customers through more than 20 local offices.

The economics of the prairie provinces have grown dramatically over the last 50 years. No longer are they solely based on agriculture. They have industrialized, and two of the three have become relatively wealthy. The federal government must ask itself if the PFRA role remains appropriate to it.

Alberta has been assuming a stronger role in farm water management. In 1973, it agreed to assume the operations of

Table 10.1

PRAIRIE FARM REHABILITATION ADMINISTRATION

APPENDIX 1 EXPENDITURES AND REVENUE BY ACTIVITY[1]

	1980-81	1981-82	1982-83
Expenditures			
Headquarters Analysis, Planning and Program Development	$ 1 760 548	$ 1 747 026	$ 1 624 072
Headquarters Administrative Services	2 024 511	2 778 254	3 259 214
Engineering Technical Services	6 686 521	7 531 597	8 647 043
Soil and Water Conservation Technical Services	-	329 060	594 415
Construction Service Operations	709 342	849 512	890 853
Water Development Program Administration	2 453 260	2 921 826	3 413 291
On-Farm Water Development	4 238 247	5 783 356	4 904 613
Small Community and Group Water Development	—	111 418	619 216
Community Pasture Administration and Operations	7 427 723	7 839 147	8 908 640
Community Pasture Improvement and Development	2 226 953	1 572 414	1 488 212
Tree Distribution	2 000 071	1 812 048	2 325 691
Demonstration Farm	147 259	180 759	544 509
Agricultural Service Centres	2 359 976	2 382 797	1 076 782
Water Development and Drought Proofing:			
Manitoba Agreement	173 277	1 589 411	914 882
Saskatchewan Agreement	924 902	1 715 301	3 007 394
Southwest Saskatchewan Irrigation Projects	1 040 293	1 198 241	1 532 749
Alberta Irrigation Rehabilitation	717 239	178 720	60 868
South Saskatchewan River Project	191 235	320 054	367 149
Community Water Projects Program	24 083	35 949	10 233
Assiniboine River Diking	237 611	74 043	35 217
Herd Maintenance Assistance Program Administration	1 057 860	230 249	—
Herd Maintenance Assistance Contributions	42 887 046	2 093 436	—
Emergency Water Supply Program	311 744	490 275	—
	$79 599 701[2]	$43 764 893	$44 225 043
Revenue			
Community Pasture Operations	$ 5 967 088	$ 6 912 965	$ 8 448 147
Southwest Saskatchewan Irrigation Projects	225 311	197 356	215 919
General Revenue	3 393 914	3 320 725	2 792 251
	$ 9 586 313	$10 431 046	$11 456 317

[1] Includes operational expenditures, capital expenditures and contributions

[2] Does not include write-off of working capital advance $513 739 in fiscal 1980-81

Source: PFRA Annual Report, 1982-83.

PFRA irrigation systems as restored by PFRA. Since 1978, it has not taken advantage of PFRA programs to develop water supplies for agriculture based communities. The new Saskatchewan Water Corporation seems to be planning to take a more direct role as well.

If PFRA is to continue its present roles, and the decision is a political one, restricting its sphere of operations to the original "drought and soil drifting areas in the provinces of Manitoba, Saskatchewan, and Alberta", should be reconsidered. Indeed, PFRA has already operated in other dry areas such as Kamloops and Penticton in British Columbia. If federal assistance is to be made available to farmers and ranchers in one drought-prone area, it would only be equitable to extend the services to all drought-prone areas.

> IT IS RECOMMENDED that if the programs of PFRA are to be continued, they be extended to encompass all drought-prone areas of Canada.

(b) PFRA Programs and Federal Water Policy

As already noted, PFRA sees itself as a development agency serving local needs in response to provincial requests within their sphere of jurisdiction. Within this context, it may not find national water policies of the federal government particularly relevant to its own programs. It has its own legislated mandate to develop water resources for local use to mitigate the effects of drought. This independent approach was demonstrated in 1982 when PFRA sought the approval of the federal government to initiate new irrigation programs without first having submitted the proposals to the Interdepartmental Committee on Water (ICW). The role of the ICW is to review all major federal water initiatives to ensure that they fit within the federal water policy framework. In the end PFRA was advised to submit its proposals for ICW review.

The principal issue is that the federal government's perspective, being national or regional in scope, differs from that of a province. While a province would wish to obtain the maximum benefits from its share of a limited resource, the federal government would be interested in maximizing benefits within the region, the Saskatchewan-Nelson basin in this instance. If a unit volume of water would be worth more generating electricity in Manitoba than in growing crops in Saskatchewan, the federal government would presumably favour the former. How can such differences be accommodated?

First, there is nothing to prevent a downstream province from negotiating with an upstream province and offering to buy the flow that would otherwise be consumed through an irrigation program. Such negotiations would be based on the interests of individual provinces however, and the result of an interprovincial negotiation still might not be the most desirable from the regional or national perspective.

Second, the federal government could encourage formulation and adoption of a regional strategy, or plan against which major water development proposals would be judged. History suggests, however, that the individual prairie provinces might not be particularly interested in joining such an approach. The federal government tried to sell the idea during the discussions that over 20 years finally led to the apportionment agreements among the provinces. Central to those agreements was assurance to each province of a specified share and a right to decide independently on how that share was to be used.

Thirdly, the federal government could develop a comprehensive set of criteria that it would employ in analyzing the economic and social benefits and costs of water development proposals. These criteria would be explained to the provinces, preferably developed with their help. They would be used as the bases of analyses upon which the federal government would base its assistance decisions. This approach would be less intrusive on provincial rights than any of the others. It would also provide for responsible use of federal resources.

> IT IS RECOMMENDED that the federal government, in consultation with the provinces, develop and adopt a comprehensive set of criteria on which to base socio-economic analyses of water development proposals that would be used to guide federal program assistance decisions, including those respecting PFRA.

Adoption of this less intrusive role would leave the federal government with its vital role of honest broker or conciliator in interprovincial disputes.

11. REGIONAL WATER QUALITY MANAGEMENT

11. REGIONAL WATER QUALITY MANAGEMENT

11.1 Introduction

The federal government became involved in regional water quality management issues in the 1960's through the comprehensive river basin planning agreements introduced under the Canada Water Bill and a Canada-United States reference to the International Joint Commission concerning the quality of the lower Great Lakes. Federal-provincial river basin studies of the Okanagan, Qu'Appelle and Saint John rivers led to the identification of serious pollution problems and implementation agreements to effect pollution control measures, primarily municipal and industrial waste treatment facilities.

In some instances, federal-provincial planning agreements under the Canada Water Act focussed entirely on water quality issues. The Canada-Quebec agreement on the St. Lawrence River, 1972-1978, was of this nature, with the objective of preparing a plan to reclaim, protect and improve the water quality of the River. The implementation of that plan rests primarily with the Province, although the federal government contributed financially for sewage collection and treatment at Montreal and discussions are continuing that may lead to other federal-provincial cooperative measures.

A more complex regional water quality management endeavour is the Canada-British Columbia Fraser River Estuary Study initiated in 1977. The objective of this study was to develop a management program to guide future changes in the estuary so as to preserve and protect its environmental attributes while continuing its development as an economic resource. This integrated study of land and water use has involved a large number of federal, provincial and municipal agencies and many interest groups. It has led to the production in 1982 of a proposed management plan for the estuary

that incorporated broad objectives, policy guidelines, and a recommended committee structure to move forward with more detailed planning and management of the estuary.[1] It is anticipated that a federal-provincial agreement to establish a management committee structure will be signed in 1985.

The major federal comprehensive involvement in regional water quality management, however, remains on the Great Lakes.

Although the first comprehensive report on pollution in the Great Lakes system was issued by the International Joint Commission in 1918, the current program has its origin in a joint Canada-United States reference to the IJC in 1964. The IJC was asked to determine whether Lake Erie, Lake Ontario and the international section of the St. Lawrence River were being polluted to the extent that injury to health or property was occurring. The IJC established advisory boards of representatives from the governments of both countries, bordering states and Ontario.

The advisory boards reported to the IJC in 1965 and submitted final reports in 1969. These led to an IJC report and recommendations to the two countries primarily concerned with municipal and industrial pollution with emphasis on eutrophication and the need to reduce the amounts of phosphates entering the Lakes.

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1 Canada-British Columbia, 1982. A Living River by the Door. A Proposed Management Program for the Fraser River Estuary. B.C. Ministry of Environment, Surrey, B.C.

The first Canada-Ontario Agreement Respecting Great Lakes Water Quality was signed in 1971, reflecting the terms of agreement being developed between Canada and the United States that was finalized the following year. The initial Canada-Ontario Agreement was to cover a five-year period, but was extended on two ocassions and expired in 1982 when replaced by an entirely new agreement.

The initial agreements related primarily to the provision or upgrading of municipal sewage treatment systems with special measures for the removal of phosphates. Ontario agreed to require and assist municipalities to undertake the required measures and Canada provided financial assistance through CMHC. Other aspects of the first agreement related to work Ontario was to carry out to assist Canada in meeting its international obligations and the financial contributions Canada would make to Ontario in that regard. Ontario assumed responsibility for surveillance in the nearshore areas and research programs related to the impacts of urban drainage and the effects of the municipal pollution abatement program.

Related to these agreements Canada included a measure in the Canada Water Bill to permit the regulation of nutrients in household detergents and other cleaning agents. When the Bill was enacted, a regulation was issued limiting the concentration of phosphates in laundry products.

During the course of the original agreements, additional research by Canada and the United States led to the identification of new priority concerns, particularly toxic chemicals, and the need to adopt a comprehensive ecosystem approach to Great Lakes water quality management. On recommendations from the IJC, a revised Great Lakes Water Quality Agreement between Canada and the United States was signed in 1978.

11.2 The Great Lakes Water Quality Program

11.2.1 Objectives

The fundamental purpose of the Canada-U.S. and Canada-Ontario agreements "is to restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes Basin Ecosystem" through a maximum effort to develop a better understanding of the ecosystem and to eliminate or reduce to the maximum extent possible the discharge of pollutants into the Great Lakes System. In particular, Canada, the United States and Ontario adopted the policy that: "the discharge of toxic substances in toxic amounts be prohibited and the discharge of any or all persistent toxic substances be virtually eliminated".

The agreements specify five general water quality objectives for the Great Lakes system including freedom from:

(a) substances that will settle and form putrescent or otherwise objectionable sludge, or that will adversely affect aquatic life or wildlife;

(b) floating materials in amounts that are unsightly or deleterious;

(c) materials or heat that will produce colour, odour, taste or other conditions interfering with beneficial uses;

(d) materials and heat that along or in combination with other materials will produce toxic or harmful conditions for man, animal or aquatic life; and,

(e) nutrients in amounts that create growth of aquatic plants that interfere with beneficial uses.

11.2.2 Program

To meet the defined objectives, the Canada-United States Agreement contains the elements of 13 programs addressing:

(a) pollution from municipal sources - construction and operation of municipal waste treatment plants, including pretreatment requirements for industrial users;

(b) pollution from industrial sources - establishment of waste treatment or control requirements consistent with the achievement of the general and specific water quality objectives, and including requirements for the substantial elimination of persistent toxic substance discharges;

(c) inventory of pollution abatement requirements - including compliance schedules and status of compliance;

(d) eutrophication - construction and operation of municipal waste treatment facilities to meet specified objectives and reduction of phosphorus introduced from diffuse sources;

(e) pollution from agricultural, forestry and other land uses - including measures to regulate use of pesticides, measures to reduce animal-waste runoff, measures governing the hauling and disposal of wastes, review and supervision of road salting practices, control of soil losses, and incorporation of Great Lakes water quality objectives in land use planning;

(f) pollution from shipping - adoption of compatible regulations respecting the discharge of oil and other wastes from shipping and the establishment of a coordinated surveillance program;

(g) pollution from dredging activities - including development of criteria for identifying polluted sediments and compatible programs for the safe disposal of dredged material;

(h) pollution from onshore and offshore facilities - including programs and regulations for preventing discharges of oil and hazardous substances;

(i) hazardous polluting substances - maintenance of a list of such substances and measures to eliminate the risk of release thereof;

(j) persistent toxic substances - control programs for their production, use, distribution and disposal, including an inventory of sources, coordination of air, water and solid waste disposal programs, and joint Canada-United States disposal program;

(k) airborne pollutants - identification of sources and consultation on remedial measures;

(l) surveillance and monitoring - coordinated programs to assess compliance with pollution control requirements to assess achievement of objectives and to identify emerging problems; and,

(m) contingency plan - a joint plan to contain and clean up discharges of oil and hazardous polluting substances.

11.2.3 Canada-Ontario Agreement

The 1982 Canada-Ontario Agreement Respecting Great Lakes Water Quality reflects the revised Canada-U.S. Agreement. In essence, the Canada-Ontario Agreement calls for maximum

efforts to develop a better understanding of the Great Lakes ecosystem and the elimination or maximum practicable reduction of the discharge of pollutants with emphasis on toxic substances and the completion of the municipal waste treatment program.

Terms of the Agreement provide for Canada to pay 50 percent of surveillance programs undertaken by Ontario as part of Canada's commitment under the Great Lakes International Surveillance Plan and 50 percent of approved research programs undertaken by Ontario. The maximum annual shareable costs are set at $2.4 million.

In addition, Canada agreed to contribute $65 million for the completion of a municipal waste treatment plant construction program to achieve the specific water quality objectives, including phosphorus reductions, agreed to by Canada and the United States.

The Agreement also provides for information exchange, coordination of programs and work sharing on certain programs.

The Ontario Government continues its responsibility for water quality surveillance in the nearshore of the effects of municipal, industrial and other waste discharges, and of the inflows of tributary waters, all as identified through the Great Lakes International Surveillance Program.

11.2.4 The Federal Roles

The major federal roles in the Great Lakes Water Quality Program are surveillance of water quality and the contamination of fish in the open lakes, research, and the regulation

of pollution from commercial shipping. The departments involved are Environment, Fisheries and Oceans, Health and Welfare, Transport, Public Works, and Agriculture. Environment Canada's activities are shared by the Inland Waters Directorate, Canadian Wildlife Service, the Environmental Protection Service, Atmospheric Environment Service, and the Lands Directorate. Principal activities include the following:

DOE - surveillance of water and biota chemistry of open lakes, analytical laboratory services;

- lakes research respecting: wave action and impacts on shorelines and sediment movement; methodology in chemistry and microbiology for the analysis of pollutants in water, sediments, plants and animals; toxic chemicals characteristics, pathways and fates; aquatic recycling of nutrients; biochemical processes within the Lakes; environmental simulation modelling; groundwater contamination by toxic chemicals and their movements;

- monitoring of biotic accumulators of toxic substances;

- monitoring of atmospheric deposition of contaminants in the Lakes;

- research respecting waste treatment technology; and,

- research respecting the accumulation of contaminants in sediments, their recycling into the water column when disturbed, the contamination of sediments in dredging areas, disposal of dredged materials.

DFO - provision of ships for open lake surveillance programs;

- surveillance of contaminants in commercial, sport and forage fish; and,

- research to identify impacts of new chemicals, pathways of toxic into fish populations, identification of contaminated fish populations.

NHW - toxicity studies of substances found in the Lakes; and,

- advice to federal and provincial agencies on human health implications of contaminants.

MOT - development and enforcement of regulations respecting pollution from commercial shipping and related shore facilities.

DPW - manage dredging activities and sample dredged material for contaminants.

DOA - research into implications of agricultural practices on nutrient runoff to the Lakes.

Frustrations have been expressed about the limited role of the federal government in implementing the Canada-United States Great Lakes Water Quality Agreement. The federal role is primarily one of research, surveillance and the provision of funds to Ontario to undertake surveillance programs on behalf of Canada and to assist with capital expenditures for municipal sewage treatment plants. Implementation of actual control measures have been left to the Province. For other than a few substances, such as PCBs, little federal regulatory control is in place for the more than 800 substabces that have been identified in the Great Lakes, many of which may be toxic.

The situation arises from Canada's constitutional framework and provincial insistence on retaining authority over natural resources and local works and undertakings. Provinces do not wish direct federal involvement with pollution control regulation, be it from municipal, industrial or agricultural sources. This became abundantly clear more than a decade ago when Environment Canada's Environmental Protection Service began using Section 33 of the Fisheries Act to promulgate national effluent quality regulations for various industries and began to deal directly with individual plants to set pollution control requirements. Provinces perceived this activity as an attempt by the federal government to usurp water pollution control responsibilities from them, and an undesirable duplication of effort. The results have been a shifting of the federal role to a greater concentration on pollution control technology, development, technology transfer, and advocacy of environmental protection measures. In addition, federal-provincial accords on environmental protection were entered into with most provinces in 1975. Under these arrangements, Environment Canada agreed to work through the provinces on pollution control matters on the understanding that provinces would require control measures at least as stringent as agreed upon national baseline requirements. In addition to all this, the administration of the Fisheries Act had been transferred to inland provinces, including Ontario, some year ago.

Thus, the federal concerns. They have few legal tools with which to effect pollution control and one that they have, the Fisheries Act, is administered by Ontario and has hardly ever been used in a prosecution. While Canada must negotiate with the United States on international matters involving pollution control requirements in both countries, it cannot point to Canadian national control legislation that matches that of the United States.

There is a solution, an appropriate federal role, an avenue that the federal government has pursued in the past with provincial support. This has been to control potential pollutants of national significance at source. The Environmental Contaminants Act, Pest Control Products Act and Canada Water Act have been used to control the manufacture, importation and use of substances dangerous to human health and/or environmental quality. It has already been recommended in Chapter 2 that the Environmental Contaminants Act be amended to provide a registration process for chemical substances so that importation, processing, manufacture or use of those considered dangerous to human health or the integrity of the ecosystem may be prohibited or allowed under specific regulated conditions. Canada requires such legislation if it is to respond adequately to a 1980 recommendation of the IJC calling for the prohibition of the production, sale, transport or use of persistent synthetic organic compounds with known highly toxic effects whose use will result in their entry into the environment.

11.2.5 Financing the Program

In 1983-84, total federal funding for activities by its own agencies amounted to approximately \$9.6 million. Of this amount, some \$4.6 million was used by the Inland Waters Directorate for surveillance and research. Of the remaining \$5.0 million, Fisheries and Oceans accounted for about \$3.0 million, Health and Welfare, \$1.0 million, and the other agencies, \$1.0 million.

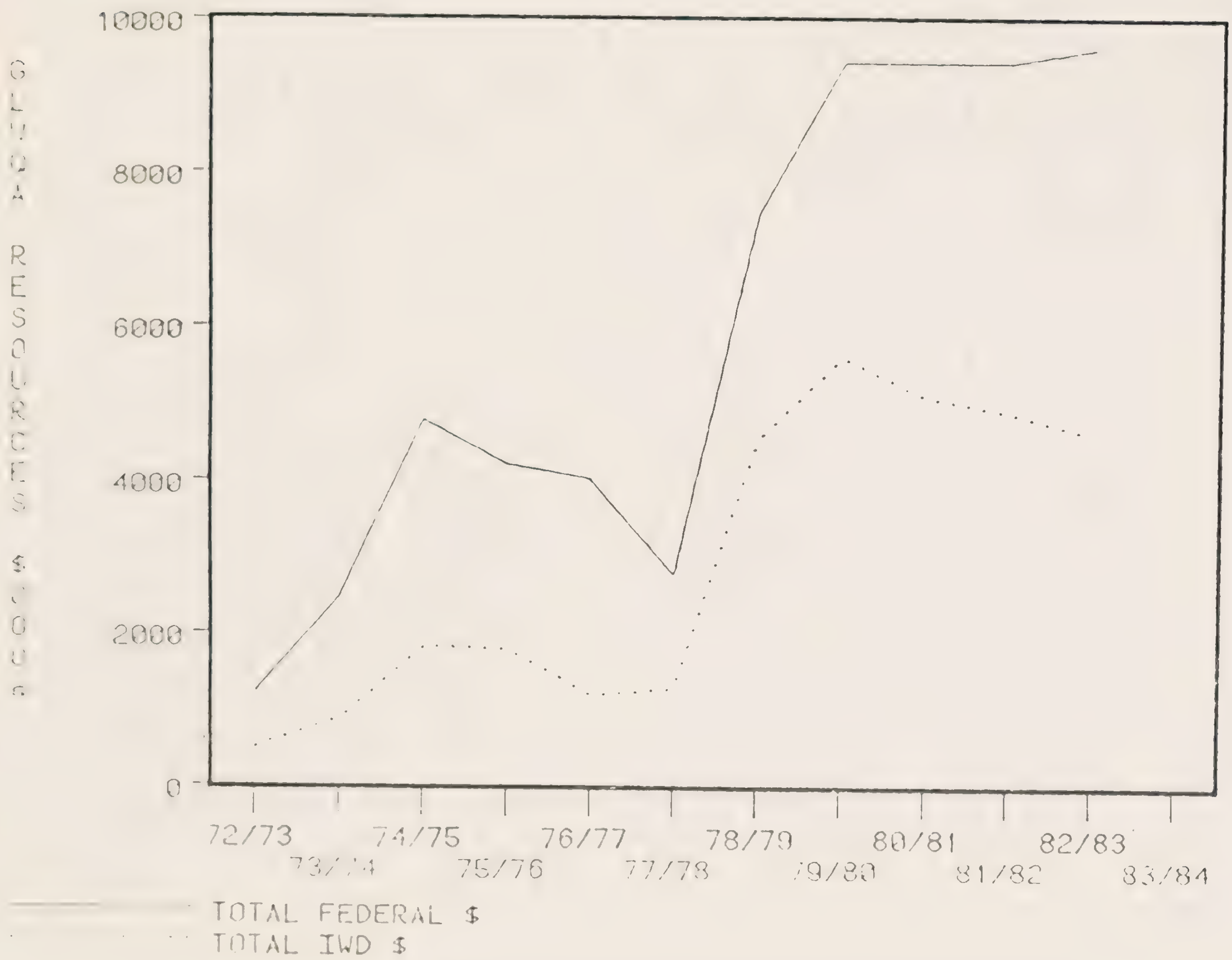
It has been estimated that about 60 percent of these expenditures are related to the toxic substances issue.

The accompanying chart depicts the changes in expenditures over the 11-year period from 1972-73 to 1982-83. The sharp rise in expenditures in 1978-79 and 1979-80 reflected the revised Canada-United States Agreement and the new emphasis on toxic chemicals and the adoption of a broad ecosystem approach to water quality management. Environment Canada's expenditures reached a peak in 1979-80, declining gradually since that time by a total of close to 20 percent. While some of this decline may be due to the government's financial restraint programs, some of it is known to be based on decisions that shifted some emphasis from the research program at the National Water Research Institute to the development of water quality objectives and the development of new agreements with Ontario. At the same time, the total federal commitment to the Great Lakes Program has not declined over the same period, suggesting changes in emphasis among programs of various agencies rather than the impact of financial restraint.

Financial problems do exist, however. For example, the Canada-Ontario Agreement provides for equal cost sharing of surveillance programs carried out by Ontario in support of Canada's commitments with the United States. Insufficient provision was made for rising costs which have risen to the extent that costs to Ontario have reached $3,2 million annually, while the shareable total was fixed at $2.4 million.

> IT IS RECOMMENDED that Canada adjust its commitment under the Canada-Ontario Agreement to return to the principle of equal cost-sharing of surveillance carried out by Ontario in support of Canada's international obligations.

FEDERAL AND IWD* RESOURCES FOR GLWQA ACTIVITIES



* IWD - Inland Waters Directorate, Environment Canada.

It is understood that a recent unpublished study for the Auditor General was critical of research projects at the National Water Research Institute in that some were more oriented to fundamental research than to the needs of clients. A shift in research program emphasis is antici-pated, and this should help overcome the shortfall that may have developed in the Great Lakes Program's research needs.

There are also new areas of concern that have yet to be addressed that will require new resources. In 1980, the IJC presented a report with recommendations to the govern-ments on "Pollution in the Great Lakes Basin from Lake Use Activities". This report recommended that Canada and the United States develop a comprehensive strategy for the control of pollution from nonpoint sources. Emphasis was placed on the requirement to modify agricultural and urban practices that produce polluted runoff. Fertilization, livestock operations, urban storm sewer drainage, and erosion from construction areas were all highlighted. While all these issues are primarily within the realms of provincial jurisdiction, federal cooperation will be necessary to encourage attainment of the desired results. Incentives or subsidies may become necessary to encourage farmers to adopt new approaches to manure storage, spreading and disposal techniques. Changes that may be necessary in the use of combined storm and sanitary sewer systems will be capital intensive, requiring assistance similar to that currently provided for sewage treatment facilities. Additional water monitoring programs of tributary streams and rivers may be required to evaluate the results of non-point pollution control programs. Without these new initiatives, the Great Lakes Water Quality Program may fail to reach its objectives.

IT IS RECOMMENDED that the federal government demonstrate its support of the IJC's recommendations concerning control of non-point source pollution by providing resources necessary for departments to cooperate with Ontario in tackling the problems.

11.2.6 Institutional Arrangements

(a) International

The Great Lakes Water Quality Program has become a multi-dimensional one, moving beyond the original focus on waste-water treatment at municipal and industrial outfalls. It now encompasses land management practices in agriculture, forestry and urban development, industrial and user practices relating to toxic chemicals, development of a better understanding of the sources, characteristics and effects of toxic pollutants, and programs to eliminate their entry into the lakes. In essence the Great Lakes Water Quality Program is assuming a comprehensive water basin management approach. It still lacks the major component related to consumptive use, but the stepwise approach to comprehensive management has been inevitable and encouraging.

A large number of jurisdictions and agencies of two national governments, eight states and one province are involved in aspects of this major ecosystem management problem. Drawing the pieces together into a cohesive coordinated force to produce effective solutions has been a difficult task. At the international level, the International Joint Commission plays the key role, assembling information from experts in both countries, considering the implications, identifying problems amd recommending courses of action to the two countries. The IJC is assisted in this endeavour by the Great Lakes Water Quality Board and the Great Lakes Science Board that advise the Commission on the state of the Lakes and on the scientific aspects thereof. Although the IJC

does not have management authority to require the implementation of remedial programs, its high public profile has helped to ensure international attention to and eventual implementation of its recommendations.

From time to time, it has been suggested that the Boundary Waters Treaty should be renegotiated to define more clearly the general prohibition against pollution of waters that causes "injury to health or property" and to give more powers to the IJC. A more specific definition of pollution and its effects would be most difficult to accomplish and the end result would be a loss of flexibility that the current wording allows to the two countries working with good will. With respect to the authority of the IJC, Article X of the Boundary Waters Treaty already provides for a decision-making role for the Commission, should the nations agree to such a role with respect to a particular issue. Considering the relative development of the two countries since the Treaty was signed in 1909, it is most doubtful if Canada could achieve better terms of agreement today.

(b) Canadian

At the Canadian federal level, Environment Canada is the lead agency. Within Environment Canada, the Regional Director General of the Ontario Region serves as the focal point for managing Canada's Great Lakes Water Quality Program. He chairs a Departmental Committee charged with bringing together the expertise and resources of the various sectors of the Department to meet Canada's commitments under the Canada-United States Agreement. He chairs the Interdepartmental Great Lakes Working Group responsible for coordinating the contributions of all federal agencies. He co-chairs the Canada-Ontario Board of Review, responsible for implementing the Canada-Ontario Agreement. Finally, he serves as the

Canadian co-chairman of the international boards advising the IJC. The memberships and roles of the various co-ordinating bodies are outlined in Table 11.1.

(c) Federal-Provincial

The Canada-Ontario Agreement and coordination body, the Board of Review, are the envy of the United States Government that has not been successful in developing formal federal-state arrangements to pursue a coordinated approach to water quality improvement on the American side of the Lakes.

The Board of Review is co-chaired by Environment Canada's Regional Director General and the Ontario Ministry of Environment's Associate Deputy Minister. The Board includes three members from each government from the agencies most intimately involved with the program.

The Board's role is to administer the Canada-Ontario Agreement, reviewing the projects undertaken and recommending to Government respecting policies and programs required to meet Canada-United States water quality objectives (Figure 11.1).

The Board of Review is supported by a Coordinating Committee that includes two co-chairmen and representatives of the Board's other committees. The co-chairmen are also members of the Water Quality Program Committee of the IJC Great Lakes Water Quality Board. Thus, the Coordinating Committee is able to keep fully informed of Canadian and U.S. programs and ensure appropriate cooperation.

The Board of Review's Surveillance Committee has membership drawn from agencies involved with monitoring both nearshore and open water portions of the Lakes. The Committee undertakes an annual review of surveillance program objectives,

Table 11.1

COORDINATION OF THE GREAT LAKES WATER QUALITY PROGRAM

	DEPARTMENTAL - DOE	INTERDEPARTMENTAL	INTERGOVERNMENTAL	INTERNATIONAL
Committee/Board	GREAT LAKES	GREAT LAKES WORKING GROUP	BOARD OF REVIEW (CANADA-ONTARIO AGREEMENT)	A) GL WATER QUALITY BOARD B) GL SCIENCE ADVISORY BOARD
Reporting to	DM of DOE	ICW*	Minister of Each Government	IJC**
Membership	RDG Ontario ADMs	All federal departments: DOE, DFO, NHW, MOT, DOA, DPW, AECB, TB, FIN	Senior Federal& Provincial Officials	Senior Federal & Provincial Officials
Responsibilities	TO BE DRIVING FORCE IN DOE as stated in DOE directive of Feb. '82.	ADVISES RDG (ONTARIO) ON:	ADVISES ON IMPLEMENTATION OF C.O.A.:	ADVISES IJC:
	- develop effective policies, plans, coordinating and monitoring	- implementation of annual budget of $1.9 million	- allocation of resources, federal funds $1.2 million	a) senior advisory board to IJC concerning all aspect of the "state of the art" of the Great Lakes
	- management of resources directly under control of committee	- interdepartmental coordination of A-Bases	- Sewage Treatment Facility funds of $65 million (Schedule G of C.O.A.)	b) science aspects of Great Lakes water quality
	- negotiate commitments with DOE support managers	- establishes interdepartmental goals		
	- establish steering committee for functional guidance to interdepartmental intergovernmental international bodies			
	Chairman - DOE RDG Ontario	Chairman - DOE RDG Ontario (who is also responsible for coordinating interdepartmental activities)	Federal Co-chairman - DOE RDG Ontario (who is also responsible for federal implementation	Federal Co-chairman - DOE RDG Ontario (who is also responsible for federal implementation

* Interdepartmental Committee on Water
** International Joint Commission

Figure 11.1

CANADA-ONTARIO
GREAT LAKES PROGRAM

Federal Government
Minister of the Environment

Provincial Government
Minister of the Environment

COA BOARD OF REVIEW

Environment Canada
Regional
Director General

Co-chairmen

Environment Ontario
Associate
Deputy Minister

Secretary

Coordinating
Committee

Surveillance
Committee

Toxic
Substances
Committee

Pollution
Controls
Committee

Public
Information
Committee

plans, costs and anticipated results and recommends approval of program funding under terms of the Canada-Ontario Agreement.

The Toxic Substances Committee has federal and provincial membership drawn from all agencies working on the issue. The Committee identifies priority areas and issues, evaluates the programs of both governments for the Board, and effects exchange of information.

The Pollution Control Committee monitors research programs; pollution abatement and compliance programs; pollution from nonpoint sources, shipping, dredging; and, contingency planning. Basically, the Committee reports to the Board on progress being achieved with the various pollution control programs.

The Public Information Committee arranges publicity for Canada-Ontario Agreement programs, keeping the public informed on program activities and achievements.

In total, the Board of Review, with its supporting Committees, has provided a well-knit structure to assure mutual understanding of internal problems, encourage and effect coordination of programs, and exchange information.

(d) Federal Government

The coordinating role within a federal department or among several is a difficult one, more difficult that just a few years ago. When a new priority issue was identified a decade ago, new resources were often provided to address it. This was the case, for example, with federal-provincial river basin planning agreements. New planning studies were undertaken largely with new funds in addition to existing programs. The co-chairmen of a federal-provincial planning

board had an identified budget with which to influence the priorities of other agencies and get tasks accomplished. The chairmen not only had responsibility to undertake a program, but were accountable for the effective use of a defined budget.

Times have changed. The coordinator or chairman of an interagency program often no longer has effective control over the resources required to achieve program objectives. The Treasury Board seldom approves new funding adequate to undertake a program. Instead, participating agencies are first required to re-examine their own priorities within their basic, or A-Base, budgets, and reallocate resources to the new priority issue. After this exercise is completed, marginal new funding may then be provided for new program initiatives.

This process prevailed when the federal Treasury Board reviewed a joint submission of departments seeking resources to implement the 1978 Canada-United States Great Lakes Water Quality Agreement. A maximum annual expenditure level of $10 million was set, of which a discretionary allotment of some $1.9 million was provided for new commitments under the Canada-United States Agreement.

In some instances, the output of a particular current A-Base budget program may serve several objectives of a department. Within Environment Canada, for example, the Inland Waters Directorate's water quality monitoring program on the Great Lakes responds to requirements of the national water quality network, the national toxic chemicals control program, and the national acid rain program, as well as the Great Lakes Water Quality Program. Research program at the National Water Research Institute may be related to a variety of

objectives, including fundamental research. The important task becomes one of adjusting A-Base budget projects to accommodate the objectives of a new program.

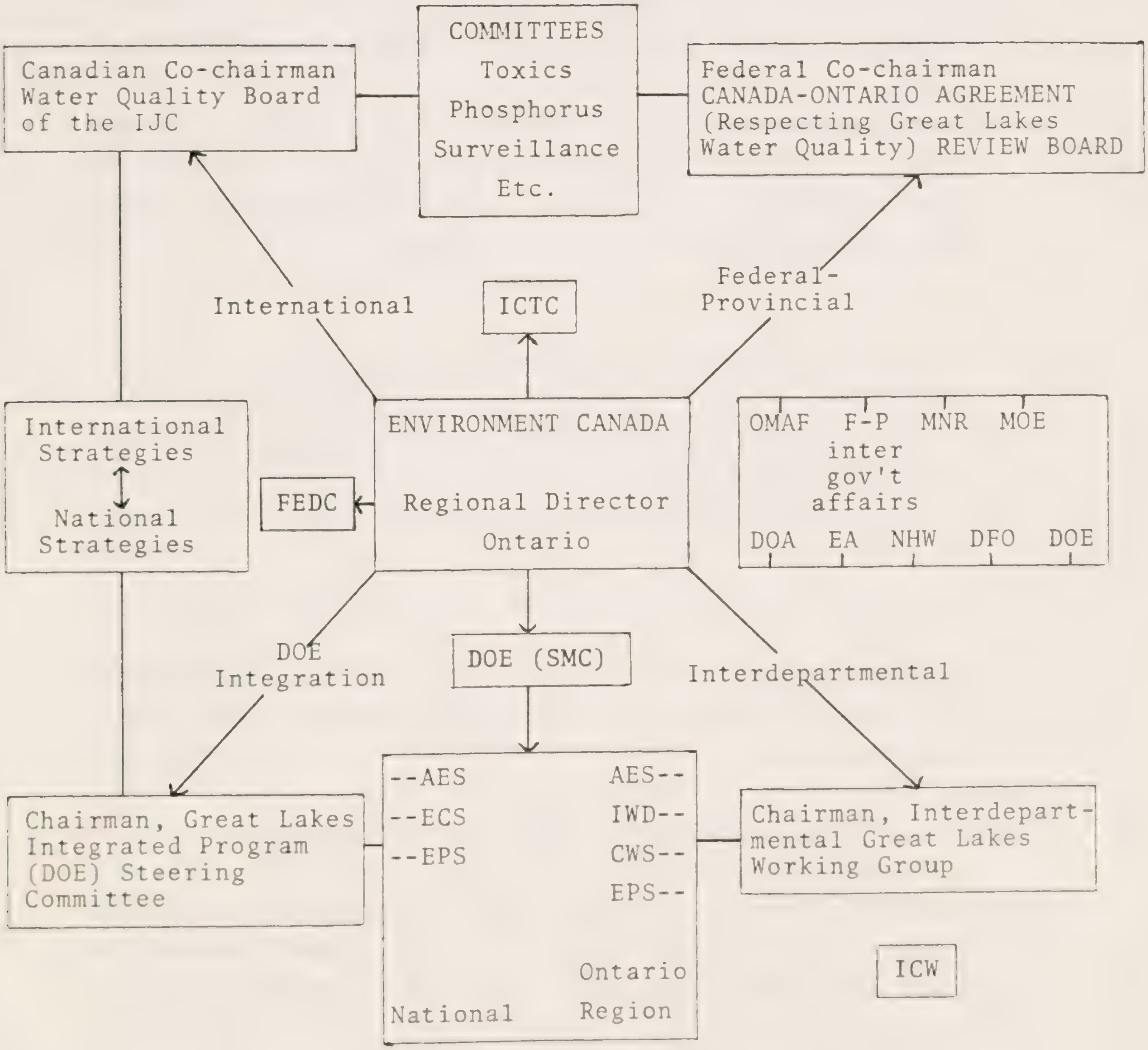
Rigidities can be overcome to an extent by judicious use of the $1.9 million of discretionary funds available to the Regional Director General and the Interdepartmental Great Lakes Working Group. Essential projects can be purchased from cooperating agencies. But if the discretionary funds are to be successfully used as a lever to effect changes in regular programs in response to the requirements of the Great Lakes Program, the members of the Great Lakes Working Group should have elements of line authority over their supporting services.

The management structure shown in Figure 11.2 is complex, but there seems to be no better alternative, particularly now that the focus of the Great Lakes Water Quality Program is shifting from the traditional control of point sources of pollution to nonpoint sources. The issues are no longer confined to water withdrawal, use, treatment and return to the watercourse. Agricultural, land development and urban maintenance practices within the basin are now parts of the scenario, as are industrial emissions to the atmosphere within and without the basin. These issues cannot be dealt with effectively by water management agencies alone. Cooperation is required of agencies and individuals with responsibilities for other natural resources, urban affairs, and economic development. The last group is particularly important for it may be through their support of industrial and urban renewal that pollution abatement is achieved as part of larger modernization programs.

Figure 11.2

FEDERAL

GREAT LAKES PROGRAM STRUCTURE



Source: Environment Canada

At the federal level a fundamental need is to ensure that the Great Lakes Program manager has sufficient resources and authority over them to implement his mandate. Within Environment Canada, this dictates the clear identification of the Great Lakes Water Quality Program as an "integrated" program, that is one to which resources of each component of the Department are specifically dedicated within departmental estimates to respond to program priorities of the Regional Director General. Thus, while the operational management of individual programs would remain the responsibility of the line managers within the Department, initial program selection for inclusion in the Great Lakes Program would rest with the Regional Director General.

> IT IS RECOMMENDED that Environment Canada treat the Great Lakes Water Quality Program as an "integrated" program, with overall priority selection and approval of components contributed by services of the Department resting with the Regional Director General and the Departmental Steering Committee.

Interdepartmentally, the Great Lakes Program would profit at the policy level from representation on a revitalized Interdepartmental Committee on Water and from designation as a priority issue by the Interdepartmental Committee on Toxic Chemicals.

11.2.7 Program Results and Future Directions

Nearly $2 billion have been invested in municipal sewerage works since the first Canada-Ontario Agreement on the Great Lakes was signed. Industry has also invested large sums.

There have been gratifying declining levels of phosphorus in Lakes Huron, Erie and Ontario. On the other hand, nitrogen loadings of Lakes Ontario and Huron show increases probably related to agricultural practices.

Herring Gull egg analyses programs have indicated declines in presence of six persistent organochlorine substances monitored, but concerns have been expressed over an apparent levelling off of the rate of decline. In some instances, contamination levels have remained essentially constant over the last few years.

The identification of the pesticide toxaphene in Lakes Superior and Huron indicate the complex dimensions of the Great Lakes Water Quality Program, This contaminant enters the lakes from airborne sources, travelling long distances from areas of use in the U.S.

Intensive surveillance programs in different sections of the Lakes systems continue to identify and trace contaminants to sources where corrective measures will be required. The most significant concern in this regard is the special Canada-U.S. study of the Niagara River that has identified a number of industrial dump sites in the United States that are leaking toxic chemicals into the River.

In general, Canadian officials directly involved with the Great Lakes Program are cautiously pleased with results so far. They see an urgent need for continued diligent application of effort, particularly to initiate programs to respond to IJC recommendations regarding nonpoint pollution, and to convince Americans to undertake clean-up operations of industrial dump sites. Concerns were expressed that reductions in financial and personnel resources assigned to the program could let successes begin to slip away. Continued diligence must be applied to the surveillance program and toxicological studies to determine the impacts of chemical contaminants found in the Lakes.

The current Canada-Ontario Agreement is coming to an end. Federal assistance for the major municipal waste treatment

program will be completed. The cooperative surveillance and research programs that have been developed since 1971 must continue to be nurtured and supported if the Great Lakes Water Quality Program is to achieve the objectives recommended by the IJC.

In response to Article X, Section 3, of the Canada-United States Agreement, Canadian and American officials will meet in June 1985, to review progress and determine priorities for continuing programs on the Great Lakes.

> IT IS RECOMMENDED that Canada negotiate a revised Great Lakes Water Quality Agreement with Ontario, building on the levels of cooperation already achieved, particularly with respect to work sharing, and focussing on the critical issues of toxic chemicals and the reduction of pollution from non-point sources, and responding to Article X, Section 3, of the Canada-United States Agreement which will have implications with respect to changes in the Canada-United States Agreement.

12. MUNICIPAL SEWAGE AND WATER FACILITIES

12. MUNICIPAL SEWAGE AND WATER FACILITIES

12.1 Introduction

On January 18, 1985, newspapers carried reports on a new study of municipal infrastructure maintenance requirements that has been completed by the Federation of Canadian Municipalities.[1] The study apparently found that the average age of sewage treatment plants in Canada is 13 years, water treatment plants 23 years and sanitary sewers 30 years. The report is to be used to support requests for higher levels of federal and provincial funding to assist municipalities in maintaining essential services, roads, sewage and water systems in particular.

While the average ages quoted for sewage and water systems are not extreme, they are indicative of a problem that is growing as the economic climate of the country continues to dictate financial restraint measures by all levels of government. The federal government's involvement with municipal water and sewage systems decreased sharply after 1980 when financial assistance programs that had been available through the Canada Mortgage and Housing Corporation (CMHC) were withdrawn.

The following paragraphs outline major federal programs that have been available to assist municipalities.

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1 Ottawa Citizen, 1985. $12B needed to fight urban rot: report. January 18, p. 2.

12.2 Canada Mortgage and Housing Corporation

Federal financial participation in municipal sewage and water systems began in 1938 with the Municipal Improvements Act (Bircham & Bond, 1984). Under this Act, a loan program was made available as an employment stimulator for a short period. Again from 1963 to 1966, as another employment stimulator, the Municipal Development and Loan Act made funds available for sewage facilities.

The major CMHC Sewage Treatment Program was initiated in 1960-61 as an amendment to the National Housing Act. Initially the new program was conceived in response to a weakening employment situation, but by the time it came into effect, employment had improved and the primary objective became pollution control. In particular, there was mounting evidence of ground water pollution resulting from construction of numerous residential subdivisions with septic services and well-water supplies.

Under the Sewage Treatment Program, low cost loans with a partial capital cost forgiveness feature were made available for construction of sewage collection and treatment works. Loans carried an interest rate some one to two percent below market rates available to municipalities. The loan forgiveness feature amounted to a grant of one-sixth of capital costs.

In 1975, the CMHC program was renamed as the Municipal Infrastructure Program and its eligibility was expanded to include regional planning for sewage and water and the provision of water supplies to newly developing areas.

In 1979, the Municipal Infrastructure Program was combined with others in a block-funding program referred to as the Community Services Contribution Program. The change to block funding was in recognition of provincial and municipal responsibility for local works and undertakings.

The three CMHC programs are summarized in Table 12.1, and the financing involved is summarized in Table 12.2. It has been estimated that between 1961 and 1980, CMHC loans subsidized about one-third of municipal capital costs for sewerage and water, and grants accounted for nearly one-tenth of those costs (Bircham & Bond, 1984). More than two billion dollars were provided as loans for some 4,500 projects, and grants totalling three-quarters of a billion dollars were contributed to 6,100 projects.

Funding for the Community Services Contribution Program was ended in 1980, removing CMHC from the financing of municipal facilities, except for a $65 million commitment transferred to Canada Water Act funding for pollution control works at Great Lakes municipalities. The government's reasoning for ending its program was based on four points[1]:

a) the question of whether it was appropriate for the federal government to continue funding services that were within provincial jurisdiction;

b) the question of the accountability of the government collecting the funds through taxation yet not being responsible for the expenditures;

c) the job creation effectiveness of the program did not match that of other programs; and,

d) fiscal restraint required reallocation of funds to programs of higher priority.

The block funding nature of the program made it difficult to ascertain whether funds were spent for intended pruposes.

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1 Robert Bockstael, Parl. Sec. to Minister of Transport. Commons Debates. Jan. 18, 1981. p. 6352.

Table 12.1

COMPARISON OF THE THREE MUNICIPAL INFRASTRUCTURE PROGRAMS

Sewage Treatment Program, 1961-1974	Municipal Infrastructure Program, 1975-1978	Community Services Contribution Program, 1979 and 1980
Objectives 1) Job creation. 2) Water pollution abatement.	**Objectives** 1) Water pollution abatement. 2) Encouragement of "... comprehensive land management and residential development in previously undeveloped areas."	**Objectives** 1) Water pollution abatement. 2) Increased provincial and municipal control over specific development programs. 3) Inter-provincial equity. 4) Greater flexibility.
Eligible Projects Construction or expansion of: 1) Sewage treatment plants in new and existing areas; 2) Sanitary trunk collector sewers in both new and existing areas.	**Eligible Projects** Construction or expansion of: 1) Sewage treatment plans in new and existing areas; 2) Sanitary trunk collector sewers in new and existing areas; 3) Storm sewers in previously undeveloped areas; 4) Water supply in previously undeveloped areas; 5) Development of regional sewerage and water plans.	**Eligible Projects** 1) Sewage trunk lines and treatment in new and existing areas. 2) Community water supply facilities for new and existing areas (trucked, as well as piped, water supplies). 3) Trunk storm sewer systems (holding tanks and any treatment facilities required) in new and existing areas. 4) Sewer and water site services provided for residential land development conforming to specified density criteria. 5) Any other capital work in the federal-provincial operating agreements. (e.g. in Newfoundland and Nova Scotia- solid waste disposal; and in Manitoba, Saskatchewan, and British Columbia- waste from energy facilities.
Ineligible Projects Internal sanitary sewers; Storm trunk sewers; Repair and maintenance of existing sewerage systems; Water supply projects.	**Ineligible Projects** Internal sanitary sewers; Repair/maintenance of existing systems; Water and storm sewer projects within existing urban areas.	**Ineligible Projects** "Works not cited in federal, provincial operating agreements."
Funding Assistance Loans to municipalities covering two-thirds of the eligible capital cost of the projects at interest rates only 1/8% more than the borrowing rate of the Federal Government (usually 1-2% below market rate). Incentive grants equal to 25% of the loan amount would be forgiven under most conditions.	**Funding Assistance** Loans to municipalities covering two-thirds of the eligible cost of projects with 25% loan forgiveness as in STP. Grants equal to one-sixth of the project cost (if financing was obtained elsewhere). High cost grants (if project costs exceed $250 per capita) for communities of small size or on difficult terrain. Funds covering 50% of the cost for regional sewerage/water plans under most circumstances.	**Funding Assistance** Grants to provinces under agreements as federal contribution to provincially-approved municipal development in sewage and water infrastructure, as well as other community services.

Source: Bircham, Paul D. and Bond, Wayne K., 1984. The Impacts on Land Use of CMHC Municipal Infrastructure Assistance, 1961-1980. Environment Canada, Lands Directorate, Working Paper No. 32.

It is also clear that the funding process weakened the public's recognition of the federal contributions to municipal services.

12.3 Regional Economic Expansion

Federal funding of municipal sewage and water facilities has been contributed under the objective of regional economic growth through several programs. For example, between 1962 and 1969, the Atlantic Development Board provided financing for services in some 50 communities and provided the entire costs of water supply systems for fish processing plants and their dependent communities.

The Department of Regional Economic Expansion Act (DREE) initiated the federal government's first truly comprehensive commitment to regional development policy. Established in 1969, DREE absorbed a number of existing programs including the Fund for Rural Economic Development, the Agricultural and Rural Development Act and the Area Development Agency.

In 1974, General Development Agreements (GDA) were signed with all provinces but Prince Edward Island for which a long range comprehensive plan was already in place. Subsidiary Agreements under the GDA's have been used to obtain federal support for numerous infrastructure developments. Depending on the needs of each region, a variety of water and waste treatment facilities were constructed. Examples include a new water supply for metropolitan Halifax-Dartmouth, water and sewage facilities for smaller communities, such as Sudbury and North Bay, sewage facilities for urban centres like Regina and Montreal, and the servicing of industrial parks in a large number of communities across the country.

Industrial systems were also supported, including the upgrading of waste treatment systems of pulp and paper mills under agreements to assist the modernization of older plants. New or expanded water supplies were provided for fish processing plants in the Maritimes.

Unfortunately, a comprehensive listing of water and sewerage facilities contributed to by DREE is not readily available, but the contribution was significant, particularly in Atlantic Canada.

The expired GDA's are now being replaced by Economic and Regional Development Agreements under DRIE, the successor of DREE. The future inclusion of assistance for municipal infrastructure under these agreements is uncertain.

12.4 Prairie Communities

When DREE was formed in 1969 and regional development programs consolidated within it, the Prairie Farm Rehabilitation Administration (PFRA) maintained its identity and became DREE's principal arm for programs involving community water and sewage services in the three prairie provinces. PFRA had already been involved in the development of dams and dugouts for community water supplies, but new Agricultural Service Centres Agreements were signed in 1972. Under this program, the federal government contributed some $54 million for water and/or sewage services for about 50 communities with population over 2,000. The viability of these centres was considered essential to support agricultural growth in their localities. (Major urban centres of Winnipeg, Regina and Saskatoon and others in Alberta were not covered by this program.) Agreements expired with Alberta in 1979, Saskatchewan in 1983 and Manitoba in 1982. PFRA contributed

$28 million for 26 centres in Saskatchewan, $20 million for 15 communities in Manitoba, and $6 million for several towns in Alberta. The federal government's share of costs seems to have varied from about 70 percent in Manitoba to 90 percent in Saskatchewan.

Under 1979 Interim Subsidiary Agreements on Water Development for Regional Economic Expansion and Drought Proofing, water supplies were constructed for communities of fewer than 2,000 inhabitants. The agreements renewed community water supply programs that had been in effect for some time and covered work to be completed by March 31, 1983. Cost sharing was on a 50:50 basis with engineering design services supplied by PFRA and required lands provided by the provinces. Total federal costs for construction were $5.3 million in Saskatchewan and $2.725 million in Manitoba. Alberta did not enter into an agreement.

Late in 1984, Canada and Saskatchewan signed a new $32 million Subsidiary Agreement on Agricultural Community Water Infrastructure to renew community water development programs. A similar agreement is being discussed with Manitoba. Although now a part of Agriculture Canada, PFRA will be the federal agency implementing these agreements.

The scale of PFRA's involvement with community water supplies is impressive. In Saskatchewan, for example, about 900 community water supply projects have been completed. The number is much smaller in Manitoba where about 50 community water supplies have been built. Alberta has not expressed interest in cooperative programs for community services in recent years.

12.5 Comment

The major federal assistance programs for municipal sewerage and water systems have been offered through CMHC, DREE and PFRA. Objectives of federal involvement have included direct employment generation, pollution control, residential development, industrial development, agricultural support, and meeting treaty obligations. Behind all these objectives is undoubtedly a recognition of the inadequacy of municipal taxation powers to defray the costs of infrastructural needs.

Municipal infrastructure clearly falls within the ambit of provincial responsibility for local works and undertakings.

Whether or not the federal government should initiate new programs to support sewerage and water systems obviously involves issues much broader than federal water policies. In addition to fundamental questions regarding municipal financial capabilities, there are questions of equity among communities which deserve to be addressed. Are the costs of developing assured municipal water supplies for prairie communities so inordinately high as to merit special treatment? Has the diversification and growth of the southern prairies reached a level at which special assistance for municipal infrastructure should be questioned? On the other hand, should the highly successful programs of PFRA be extended to the typically small agricultural communities in the Peace River region, or central New Brunswick and elsewhere in Canada? Should similar communities dependent on the forest industry be included in an expanded program? These questions are well beyond the scope of water policy. They relate more to ability to pay, equity, regional development policies and federal-provincial relations.

If there is to be federal assistance, it would seem to make sense to have but one program under which municipal water and sewage facilities might be eligible to receive assistance. In the past, some projects, such as the Montreal sewage facilities, have received assistance from more than one program. In other cases, like Halifax, major assistance has been provided to provide new water systems where no sewage treatment facilities existed even though the needs had been identified. Federal sharing of costs has varied from a low of about 17 percent under CMHC programs to 100 percent under some PFRA and Atlantic Development Board programs. While the range of assistance levels may well be justified on various grounds, the availability of a variety of programs tends to create competition among programs and "fishing trips" by those seeking assistance. A single national program with a single set of eligibility criteria would help ensure equal treatment across the country or within a province.

> IT IS RECOMMENDED that the federal government review its past and current policies of financial support for municipal water and sewage facilities and develop a single program with a comprehensive set of objectives and eligibility criteria for use on a nationwide basis.

13. TOXIC CHEMICALS

13. TOXIC CHEMICALS

13.1 Introduction

Concern has been growing over toxic substances in the environment both on a worldwide basis as focussed upon by the OECD and domestically as dramatized by the discovery of mercury in water downstream of pulp mills and chlor-alkali plants, and arsenic in water supplies near gold mine areas, and mirex, dioxins and other toxic chemicals in the Great Lakes. The greatest focus of public and governmental interest has been the lower Great Lakes that serve as the water supply for some six million people, including 4 million Canadians. With respect to the Great Lakes, Canada joined with the United States in 1978 in adopting a policy to prohibit the discharge of toxic substances in toxic amounts and to virtually eliminate the discharge of any or all persistent toxic substances.

Environment Canada defines toxic chemicals as

> "those substances which, when released to the environment, or thereafter if chemically transformed through combination or otherwise, could pose a significant threat to natural ecosystems or to human health and well-being."[1]

The Revised Canada-United States Great Lakes Water Quality Agreement (1978) definition of a toxic substance is one

> "which can cause death, disease, behavioural abnormalities, cancer, genetic mutations, physiological or reproductive malfunctions or physical deformities in any organism or

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1 Environment Canada, 1980. Toxic Chemicals Management Program.

> its offspring, or which can become poisonous after concentration in the food chain or in combination with other substances."

There are some 65,000 chemicals produced commercially worldwide, only a small proportion of which have been subjected to exhaustive toxicological screening. Some 200 to 1,000 new chemicals enter world markets each year and the costs of testing one can be in the order of $1.5 million. The task appears immense.

Unlike the majority of programs discussed to this point, toxic chemicals management is not a discrete problem that can be dealt with effectively by a single agency of government. The topic is simply too broad, the impacts too diverse and the management options too variable. The key to dealing successfully with toxic substances in the environment is to subdivide the subject into component issues, each large enough to attract attention but small enough to be susceptible to solution. Major responsibility for dealing with each issue should then be assigned to a single agency with authority to draw on the skills of others as required.

On reviewing its roles with respect to toxic substances in general, the Government found that some 58 Acts were involved, administered by 24 departments, with programs coordinated by at least 80 mechanisms. At the same time, an overall guiding policy was found lacking. Four key departments were identified: Environment, National Health and Welfare, Fisheries and Oceans, and Agriculture. The four developed terms of reference for a formal Interdepartmental Committee on Toxic Chemicals, proposals for the collective interdepartmental tackling of problems, and a policy framework to guide federal departments involved in the management of toxic chemicals.

In January 1984, the Government approved the formation of the Interdepartmental Committee on Toxic Chemicals (ICTC) for an interim three year period. The Committee was instructed to prepare and recommend federal action plans on five priority issues: dioxins, drinking water safety, pesticides, contaminants in fish, and indoor air quality. Four of the five issues are directly related to water management.

13.2 Interdepartmental Committee on Toxic Chemicals

13.2.1 Purpose

The role of the ICTC is to identify major issues arising in the toxic chemicals areas, develop overall policy and a coordinated approach to managing toxic chemical activities in respect to the federal government as a whole, and provide authoritative advice to Ministers on major policy and resource allocation questions.

The ICTC does not usurp the line authority of departments; nor does it preclude existing procedures whereby departments work with central agencies, such as the Treasury Board.

13.2.2 Membership

Membership of the ICTC includes senior officials from 11 departments: Environment (Chair) National Health and Welfare Agriculture Fisheries and Oceans Transport Indian Affairs and Northern Development National Research Council Consumers and Corporate Affairs Regional Industrial Expansion Labour and External Affairs. Observer status is provided for several central agencies including Treasury Board and the Privy Council Office.

13.2.3 Policy Objective

The objective developed by the ICTC and adopted by the Government is:

> "To manage chemicals in Canada in a manner that permits enjoyment of the economic and social benefits that accrue from their production, trade and use while achieving and maintaining a condition of the environment necessary for the health and well-being of human beings, protection and conservation of natural resources and the health and diversity of species and ecosystems, now and in the future."

This objective implies that:

(a) the chemical industry would contribute to the economy;

(b) chemicals would be available to contribute to productivity in manufacturing, agriculture, forestry, mineral and other resource sectors; and,

(c) chemicals would be available to contribute to human and animal health and well-being,

while:

(a) permitting environmental quality goals to be achieved through remedy of adverse impacts of chemicals now in the environment;

(b) preventing future problems from arising in the production, distribution, use and disposal of chemicals; and

(c) ensuring health and safety of people.

13.2.4 ICTC Strategy

(a) Risk Assessment

Canada is a party to the 1981 OECD decision on the mutual acceptance of data in the assessment of chemicals and subscribes to a 1974 OECD recommendation that prior to marketing of chemicals and chemical products, their potential effects on man and his environment be assessed. To ensure consistency in testing requirements of federal agencies and that they meet international obligations, the ICTC will review procedures used by departments to identify and estimate hazards.

(b) Risk Management

Risk management involves balancing various social and economic benefits against health and environmental risks to predict the consequences of alternative actions and to select the optimum strategy.

The ICTC will develop and implement procedures for determining which federal statutory authority would be most appropriate to use in response to a given problem.

The ICTC will also review various alternative and supplementary approaches to direct regulation and examine their effectiveness under different circumstances.

(c) Compliance and Enforcement

The ICTC will review federal agency inspection activities to improve coordination of monitoring and regional laboratory services.

(d) Priorities for Action

The ICTC is charged with the identification of special issues that merit priority for interdepartmental collaboration. For those issues, the Committee will develop coordinated action plans that address the resource requirements of the agencies involved.

(e) Research

The ICTC coordinates research for the three-year action plans on special issues and promotes research and development of clear technologies for chemical production, recycling and recovery processes.

13.2.5 Principal Roles of Main Agencies

DOE - monitoring the aquatic environment for presence levels and effects of toxic substances.

characteristics research on toxic substance pathways, transformations, chemical characteristics, bioaccumulation, toxicity to biota, eventual environmental fate, damage to aquatic communities.

inventory of potential sources of toxic substance release into the environment incorporating an analysis of the commercial life cycle of types and quantities of toxic chemicals including waste residuals released or with a potential of release to the environment.

assessment of potential effects of toxic substances on environmental health, and priority-setting for action.

control information and warnings to public, provinces and industry, identification of remedial measures, identification of substitutes, regulation of waste management under Section 33 of the Fisheries Act, regulation under Environmental Contaminants Act.

advice (a) to Agriculture on pesticides registration
(b) to Transport on transportation of dangerous goods
(c) to AECB on environmental implications of waste management in nuclear industry
(d) to National Health and Welfare on newly identified toxic substances
(e) to Indian Affairs and Northern Development on waste management requirements for inclusion in water use licences
(f) to External Affairs and IJC concerning Boundary Waters Treaty obligations and Canada-U.S. Agreement on the Great Lakes, and others.

NHW - characteristics research on toxicity to humans, bioaccumulation, and health criteria

assessment of potential impacts on humans

control through drinking water quality guidelines

advice (a) to Agriculture on pesticides registration
(b) to Environment on toxicity and other environmental contaminants
(c) to Fisheries and Oceans on edibility significance of contaminants in fish
(d) to Environment on Great Lakes Water Quality
(e) to Transport on transportation of dangerous goods.

DOA - <u>assessment</u> of efficacy and risks of pesticides with respect to agricultural productivity and product marketing.

<u>control</u> of pesticides through registration under the Pest Control Products Act, including formulations, acceptable levels of contaminants, use categories, application methods.

DFO - <u>monitoring</u> of toxic substances in commercial and sports fish, food chains and habitat.

<u>characteristics</u> research on exposure, bioaccumulation and effects of substances on fish.

<u>assessment</u> of fish edibility, marketing risks, fisheries productivity.

<u>control</u> measures through industrial waste disposal requirements under the Fisheries Act.

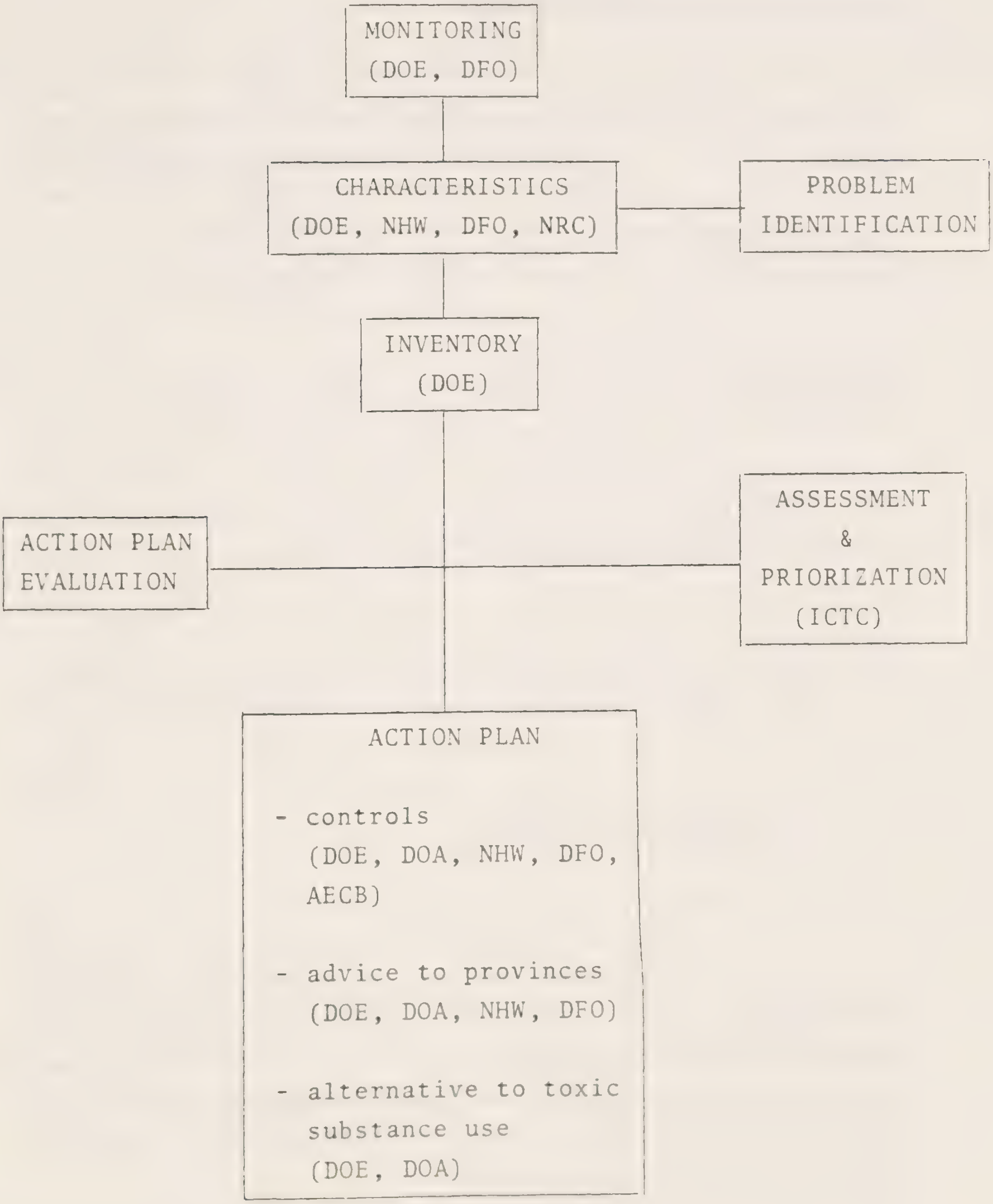
<u>advice</u> (a) to Environment on industrial and municipal waste treatment requirements for implementation under Fisheries Act
(b) to Agriculture on registration of pesticides
(c) to Environment on implications of toxic substance contamination on the health and marketability of fish.

DOT - <u>control</u> through regulations under the Transport of Dangerous Goods Act.

DIAND - <u>monitoring</u> and surveillance of industrial waste management in the North.

<u>control</u> through waste management requirements contained in water use licences in the North.

TOXIC CHEMICALS MANAGEMENT



13.3 Toxic Chemicals Action Plans

The first task assigned to the ICTC has been to develop three-year action plans for five priority issues: drinking water safety; dioxins; pesticides; contaminants of fish; and, indoor air quality. Leadership roles have been assigned, collaborating departments identified, issues defined, and proposed strategies outlined. Comprehensive strategies are being developed.

These issues are not mutually exclusive. Pesticide management practices, for example, affects the presence of dioxins in pesticides as well as the distribution of pesticidal components in the environment, including raw drinking water supplies and fish habitat.

Management by issues crosses lines of responsibility both among departments and within individual departments. The latter is particularly true for Environment.

13.3.1 Drinking Water Safety

(a) Issue

There has been a recent increase of awareness of chemical contamination of drinking water supplies focussed around leakage from U.S. toxic waste dumps in the Niagara region, pesticide infiltration into ground water and runoff into surface water supplies, and localized arsenic and contamination in mining areas.

Rapid advances in analytical methods has led to detection of trace concentrations of more than 2,000 chemicals not previously detected in watercourses. Many of these are known to be toxic, mutagenic, carcinogenic or teratinogenic.

The efficacy of water treatment technologies in removing many of these chemicals is unknown.

Chemicals used to treat raw water supplies are not subject to any regulatory quality controls.

Point-of-use, or household treatment devices are not adequately regulated.

Canada has no drinking water standards, only guidelines for some 52 parameters, only half of which are routinely monitored by provincial authorities.

The provinces jealously protect their jurisdiction over drinking water quality as a health issue, a matter of local concern.

General authority for federal involvement is found in the criminal and peace, order and good government constitutional powers. Section 5 of the Department of National Health and Welfare Act provides that the powers of the Minister extend to and include all matters relating to the promotion and preservation of health of Canadians. The Food and Drug Act provides for the regulation of health implications of food and drugs sold in Canada. By definition under that Act, water is a food. The Act was written with packaged goods in mind, however, and some of its provisions, such as those for search and entry or seizure of products, are not appropriate for application to community water supplies.

Technically, the question of regulating the quality of drinking water is not a water resource management issue. Rather, it is an issue relating to the quality control of

a water product after it has been withdrawn from nature and before it is sold or delivered for consumption. For practical purposes, however, it is a resource management matter as well, since some contaminants of raw water are not readily susceptible to removal.

(b) Objective

The objective of the federal drinking water safety program is to promote the protection of natural water quality and the appropriate treatment of drinking water supplies.

(c) Strategy

The detailed strategy being prepared by National Health and Welfare will incorporate the following elements:

(a) protection of raw water quality through guidelines for pollution control (DOE);

(b) assessing suitability of water bodies for drinking water (DOE);

(c) joint federal/provincial water quality improvement (DOE);

(d) toxicity research (including carcinogenicity) of chemical water contaminants, especially organics (NHW);

(e) epidemiological studies in areas of known contamination (NHW);

(f) surveys of drinking water for contaminants (NHW);

(g) provision of a national reference service for drinking water contaminants (NHW);

(h) provision of analytic services for some unequipped provinces (NHW, DOE);

(i) review of conventional water treatment technologies for removing chemical contaminants (NHW);

(j) development of new treatment technologies (NHW);

(k) research into alternatives to chlorination for disinfection to avoid production of carcinogenetic substances (NHW);

(l) investigation of suitability of point-of-use water purifiers (NHW);

(m) legislative proposals to control drinking water treatment chemicals (NHW);

(n) revision and expansion of "Guidelines for Canadian Drinking Water" (1978), (NHW);

(o) legislative alternatives for drinking water standards for the federal domaine (NHW);

(d) Comment

Interestingly, the federal government has the authority to regulate the "drinking" water of fish and migratory birds. It even regulates the drinking water quality of migrating people while aboard a common carrier, but not once one has arrived at a destination. Strange quirks of constitutional fate.

If there are certain levels of carcinogenicity, mutagenicity, or other category of toxicity at which the federal government is moved to act to protect Canadians from ingesting

contaminated foods and drugs, the same should apply to drinking water, whether drawn from a bottle or a tap. It is arguable that those substances that are highly toxic, disperse readily in the environment, are persistent and accumulate in the tissues of biota (including humans) are of urgent national concern, and as such are subjected to federal regulation.

In 1974, the United States passed a Safe Drinking Water Act allowing the setting of federal standards and recognizing the authority of states to enforce them. Provisions were also contained to undertake action should states fail to enforce federal standards. Provision is also made to require that the public is informed if federal standards are not met.

> IT IS RECOMMENDED that National Health and Welfare, in consultation with the provinces, establish definitions for matters of urgent national concern respecting toxic chemicals in drinking water and the treatment thereof.

> IT IS FURTHER RECOMMENDED that the federal government enact a Safe Drinking Water Act to authorize the regulation of contaminants of urgent national concern; regulation of chemicals used for water treatment; and, regulation of sale of household water treatment systems.

Many of the strategies listed above are already on-going. The detailed strategy will effect their coordination and augmentation.

The figures listed below for the lead department indicate that there has been no change in manpower allocated to the drinking water program of National Health and Welfare over

the last five years. While financial resources increased quite sharply, in current dollar terms, between 1980-81 and 1983-84, they fell by 26% in 1984-85 to return to the levels of 1982-83.

APPROXIMATE RESOURCES*
ENVIRONMENTAL HEALTH DIRECTORATE
NATIONAL HEALTH AND WELFARE

	$000's and (p/y)				
	80-81	81-82	82-83	83-84	84-85
Drinking water	491(10.3)	458(5.7)	723(8.7)	1007(11.6)	752(10.2)
Acid rain effects	22(0.1)	38(0.2)	44(0.5)	51(2.0)	27(0.5)

*Data courtesy of NHW.

While these figures may appear to be surprisingly low, it must be borne in mind that progress on drinking water requirements is closely supported by activities in other budgetary divisions of National Health and Welfare, pesticide product review and environmental contaminants, for example. The Department's 1984-85 budget provides for $1.1 million and 29 person-years work on pesticides and $2.6 million and 31.5 person-years dedicated to environmental contaminants.

First estimates suggested that the current resource allocation to National Health and Welfare for drinking water programs will need to be augmented from the current level of 10 person-years and $800,000 annually to 37 person-years and $6.4 million annually. About 4 person-years and $250,000 additional resources will be required by Environment Canada.

13.3.2 Dioxins

Coordinating Department: Environment
Collaborators: National Health and Welfare, Agriculture, Fisheries and Oceans, National Research Council.

(a) Issue

Dioxins are a group of 75 chemicals produced adventitiously with the manufacture of certain chemical products, particularly pesticides, and as a by-product of combustion.

Only two dioxins have been tested comprehensively and both have been found to be carcinogens at very low exposure levels. While most dioxins are not thought to be particularly toxic, assurance is required since they are known to be very persistent and their detection in humans and wildlife raises considerable concern.

The most toxic dioxin known, 2,3,7,8-TCDD, was found to be present in widely used herbicide 2,4,5-T. Improvements in manufacturing processes have reduced contamination to acceptable levels.

A monitoring program of herring gull eggs in the lower Great Lakes area first detected the presence of dioxins in the Lakes. The major source has been identified as industrial waste dumps of chemical plants in the United States, particularly in the Niagara River area.

(b) Objective

The objective of the Canadian dioxin program is to take immediate control action of major known sources of dioxins to minimize their entry into the environment.

(c) Strategy

The basic strategy is to identify dioxin pathways into the environment, determine effective means of preventing entry, and take the indicated preventative action.

The strategy includes a decision to put low priority on further refinements in risk assessment of individual dioxins. This decision was taken in consideration of the urgency involved and the knowledge that the assessment of the most toxic dioxin, 2,3,7,8-TCDD, involved 10 years of intensive worldwide research at a cost of some $100 million.

A major element of the strategy has been to identify sources of dioxin entry into the lower Great Lakes system and to urge the United States to require a clean-up of chemical industry waste sites leaking dioxins and other toxic substances into the environment.

An interdepartmental strategy to control dioxins within Canada was announced in December, 1983.[1] It has two major components.

The first is to control the life cycle of dioxin-containing substances, including industrial waste disposal practices. The second is to assess the potential for dioxin formation from various combustion sources.

The action plan identifies the potential pathways into the environment for each of the seven known dioxin-containing

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[1] Canada, 1983. Dioxins in Canada: The Federal Approach. Interdepartmental Committee on Toxic Chemicals, Environment Canada.

chemicals that have been used in Canada and outlines steps being taken to reduce potential problems. Stages of the life-cycle being scrutinized are registration, manufacture, formulation, transportation, storage, use and disposal. Major means of control are the Pest Control Products Act, Food and Drug Act, Transportation of Dangerous Goods Act, and the Environmental Contaminants Act. While not specifically water management acts, their successful implementation can regulate most avenues of dioxin entrance into the environment.

Registration of pesticides under the Pest Control Products Act provides for the regulation of product formulations and categories of uses permitted, such as aerial or ground application and agricultural or forestry uses. The Act is administered by Agriculture Canada with advice from Environment, National Health and Welfare, and Fisheries and Oceans. Maximum dioxin levels have been prescribed for 2,4-D and 2,4,5-T and are being investigated for tetrachlorophenol and pentachlorophenol, two wood preservatives. Registration of triclosan for limited pesticide use is being re-examined.

National Health and Welfare administers the Food and Drug Act under which the dioxin levels and use of hexachlorophene and triclosan in health care products are controlled.

All known dioxin-containing products are listed under the Transportation of Dangerous Goods Act administered by the Department of Transport. The Act provides for reasonable safety standards for packaging, handling and transporting goods, and in the case of waste products, to ensure that the correct type and quantity reaches intended destination.

The action plan calls for use of the Environmental Contaminants Act to collect information from industry to learn of possible past manufacturing of dioxin-containing chemicals and to monitor use patterns so that an inventory of possible trouble-spots may be maintained.

The historical deep-well injection disposal at pesticide manufacturing plants is being re-examined by the three provinces involved (Alberta, Saskatchewan and Manitoba). Environment Canada is investigating high temperature incineration as an alternative to deep-well disposal.

A federal-provincial abandoned waste site program is underway to determine the extent to which toxic chemicals may be creating problems. Some 4,500 sites are being assessed to determine where remedial action may be required.

Monitoring programs include analyses of commercial fish by National Health and Welfare in cooperation with Fisheries and Oceans. The latter will also monitor for dioxin contamination in other aquatic biota to determine trends.

Environment Canada, through the Canadian Wildlife Service, has been using birds eggs to monitor for contaminants including dioxins. A herring gull egg monitoring program first identified the presence of mirex and dioxins in the Great Lakes and has been used to monitor the long-term effects of control programs.

Other monitoring programs include detailed investigations of dioxins in known or suspected areas including the Niagara, Detroit and St. Clair rivers. Water and sediment analyses are conducted by the Inland Waters Directorate of Environment Canada.

In light of a vast international research effort on dioxins the Canadian action plan is limited. The current program exceeds $1 million. The objective of one project is to define the chemical properties of the higher chlorinated dioxins that determine the bioaccumulation and persistence potentials of these compounds. Another is to test the rather simple enzyme tests used to predict toxicity of dioxins. A carcinogenic study of a predicted inactive dioxin will be carried out.

(d) Comment

Initiatives available to the federal government are weakest in the waste management sphere. Both industrial and general waste disposal regulations are the responsibilities of provincial governments. While the Fisheries Act may be applicable in some instances, this would occur only after a landfill site had become defective with leakage of toxic chemicals into the ground water and thence to fish habitat.

The federal action plan provides for development of codes of good practice for waste disposal and the encouragement of their adoption by industry and by the provinces that regulate waste management.

The very nature of dioxin-containing substances dictates that control emphasis be placed on preventing them from entering the environment in the first place. Some are highly toxic. They persist for long periods. They accumulate in the tissues of biota, including man. When they enter water they dissolve, disperse and are to all intents and purposes impossible to remove through water treatment.

The federal action plan is on the right course in emphasizing viligant implementation of the Pest Control Products Act,

Food and Drug Act and the Environmental Contaminants Act. As has already been recommended, however, the latter requires strengthening to place the onus on the chemical industry to prove dioxin-free nature of its products before they are imported, manufactured or used in Canada. But even further strengthening is required. Not only should chemical products be dioxin-free, or be within approved limits, the waste products of their manufacturing must also be dioxin-free before disposal into the environment. The regulation of waste disposal of highly toxic substances would require additional amendments to that Act.

> IT IS RECOMMENDED that the authority of the Ministers of Environment and National Health and Welfare under the Environmental Contaminants Act be extended to provide for the control of manufacturing or processing of substances, when the waste products of such operations contain dioxins or other persistent toxic, bioaccumulative substances in quantities or concentrations exceeding prescribed levels.

13.3.3 Pesticides

Coordinating Department:	Agriculture
Collaborators:	Environment, National Health and Welfare, Fisheries and Oceans

(a) Issue

The insecticidal properties of DDT were not recognized until 1939. Used during World War II to control disease-carrying lice, it was not introduced commercially until 1945. Since that time, agricultural and forest management practices have intensified dramatically with a concommitant increase in use of insecticides and herbicides.

In recent years, the Canadian pesticides registration process has been placed under considerable stress resulting from several factors, among which have been:

(a) a growing number of new pesticides proposed for registration by the chemicals industry;

(b) the discovery in 1977 that one of the major pesticides testing laboratories in the US had been producing unreliable data, requiring the re-evaluation of many pesticide registrations;

(c) a need to re-evaluate widely used pesticides registered when testing methods and standards were less sophisticated than today, plus a need for still more informative testing programs.

(d) a request by Canadian forestry ministers for priority attention to 15 pesticides required to meet urgent forest renewable programs. In 1982, only the 2,4-D and

2,4,5-T herbicides were registered for forestry use and several provinces did not permit the use of 2,4,5-T;

(e) advances in analytical techniques making it possible to detect the presence of very small amounts of pesticides in the environment, in concentrations of unknown biological significance; and,

(f) pressures from interest groups seeking the banning of pesticide use, or more stringest controls; plus pressure from producers and users for a better registration system.

(b) Objective

The objective of the pesticides registration process is to regulate the manufacture, sale, storage, display, export and use of pest control products to ensure safety to human health from exposure to pesticides and their residues in foods, protection of the environment, and pesticide efficacy against identified pests.

(c) Strategy

Agriculture Canada administers the Pest Control Products Act with the advice of National Health and Welfare, Environment and Fisheries and Oceans.

In consultation with its advisor departments, Agriculture specifies the data packages of scientific information required of manufacturers when applying for registration of pesticides.

Agriculture and Forestry review the submitted efficacy data against specific pests and carry out field trials of their own. The two agencies also assess pesticide residue, fate, soil persistence and leaching characteristics.

National Health and Welfare assesses the toxicological implications for humans of each new pesticide, establishes the safety measures for those who handle the products or may otherwise be exposed to it, and determines residue limits for foods.

The Fisheries and Oceans review concentrates on fish habitat protection. The physio-chemical properties of the active ingredients and formulations are assessed with particular attention being given to rates of degradation and the products thereof, persistence and fate in water, risk of fish exposure, bioaccumulation, and the accute and sublethal responses of fish and other aquatic organisms.

The review processes of Environment Canada are designed to ensure that the environmental safety of proposed pesticides has been adequately demonstrated. The aquatic oriented review is designed to identify and quantify the likelihood of contamination of aquatic systems, including ground water and waterfowl habitat. The biological availability and toxicological significance of these exposure situations to migratory birds and other wildlife are assessed. Persistence of pesticides and their degradation products, their mobility, their potential for bioaccummulation, and their potential to disrupt ecosystems are examined. Environment Canada also recommends requirements for safe disposal of pesticide containers and leftover product.

The information available on resources assigned to the pesticides registration review process by advisor departments

is shown in Table 13.1. The recent substantial increases assigned to National Health and Welfare and Environment were in response to pressures to reduce the backlog of new pesticide applications and the re-evaluations required where original data submissions were found to be suspect. The percentage of these resources directly related to the aquatic implications of pesticides cannot be segregated.

Table 13.1

RESOURCES
Pesticide Registration Review
Advisory Departments

	80-81		81-82		82-83		83-84		84-85	
	P-Y	$000	P-Y	$000	P-Y	$000	P-Y	$000	P-Y	$000
NHW	8.7	435	8.1	448	11.5	647	17.0	990	28.8	1,132
DFO	1.0		1.0		1.0		1.0		1.0	50**
EPS[1]	1.0		1.0		1.0		2.0		8.0*	429
CWS[2]	1.0		1.0		1.0		1.0		1.0	50**

* Two not staffed   ** Estimated

1 Environmental Protection Service, DOE

2 Canadian Wildlife Service, DOE

The review processes are supported indirectly by research programs to monitor environmental pathways, fates, and bioaccumulations in fish and aquatic birds. The Environmental Protection Service of Environment Canada (EPS), for example, has a limited program to identify and assess pesticide use patterns, to monitor ground water contamination in Prince Edward Island, to analyze the levels of pesticide runoff in water and fish in selected rural watersheds, and to assess the bahaviour of pesticide residues in watercourses. Resources allocated to these projects amounts to but 3.5 person-years and some $333,000 per year. The EPS also works with provincial regulatory agencies

advising on major spray programs, assisting in "safe use" seminars with applicators and advising on disposal methods for used pesticide containers.

Fisheries and Oceans test for some pesticide residue accumulating in fish as a part of their toxic chemicals monitoring program.

The Canadian Wildlife Service monitors for selected pesticides as part of its study of toxic substances accumulating in the eggs of fish eating gulls in the Great Lakes.

Agriculture Canada is now developing a revised pesticides management plan with the collaboration of National Health and Welfare, Environment, and Fisheries and Oceans.

The action plan is expected to provide for a better coordinated and more efficient pesticides review process through:

(a) establishment of clearer guidelines to industry on the scientific data requirements for product registration;

(b) preparation of evaluation guidelines to improve consistency and impartial decisions in the review process;

(c) a priority-rating system for selecting products in use for re-evaluation;

(d) increased emphasis on determining the significance of trace amounts of pesticide residues in the environment;

(e) expanded programs to monitor use and effects of pesticides;

(f) new programs to inform the public of methods and criteria used in the pesticides evaluation process, including the risk/benefit analyses employed in the risk management process and the inherent uncertainties related to some decisions;

(g) a new approach to obtain public contributions to pest control product regulatory decisions; and,

(h) accelerated promotion and development of alternatives to chemical pesticides.

(d) Comment

Level of Effort

Canada is recognized as having one of the most stringent pesticide registration review procedures in the world. A number of countries rely on Canada's decisions respecting specific products before making their own decisions concerning use in their countries. Yet until very recently, the resources available to Agriculture's advisor departments has been seriously inadequate, resulting in a large backlog in the review process for both new products and the re-evaluation of older registered pesticides. While National Health and Welfare has received what it considers to be an adequate increase in manpower allocation, rising from 11.5 to 28.8 person-years since 1982-83, the other advisor departments' capabilities remain woefully weak and will require augmentation when the new three-year action plan is reviewed for approval.

It is important that both Environment and Fisheries and Oceans obtain adequate resources needed for responsible contribution to the registration process. At the same time, in recognition of the general scarcity of funds available to the Government, it is essential that there be no duplication of effort. In this regard, it appears that the aquatic assessment of pesticides by the Environmental Protection Service of Environment closely parallels that of Fisheries and Oceans. The two programs need review to ensure their mutual support.

> IT IS RECOMMENDED that high priority be assigned to augmenting the resources assigned to carefully coordinated pesticide registration programs of Agriculture, Environment and Fisheries and Oceans.

Placing the emphasis on the pesticide registration process is justifiable both from the problem prevention standpoint and because, once placed on the market, pesticide use is difficult to regulate. It is incumbent on those responsible for product registration to monitor the pathways, fates and effects of pesticides in the environment both to test the predictions on which registration decisions were based and to assess the adequacy of the use regulation system. As previously noted, there does not appear to be a cohesive program of monitoring, and in this regard the potential contribution of the new water quality monitoring network of Environment's Inland Waters Directorate should not be overlooked.

> IT IS RECOMMENDED that the revision of the pesticides management plan being prepared by Agriculture Canada place emphasis on developing a comprehensive program to monitor the pathways,

> fates and effects of registered pesticides to test pre-registration assumptions and assess the adequacy of compliance with registration provisions.

Responsibility Centres

The historic shortage of resources dedicated to the pesticide management process may be a result, in part at least, of the absence of a clearly legislated mandate for the ministers of National Health and Welfare, Environment, and Fisheries and Oceans to contribute to decisions under the Pest Control Products Act. Some critics go so far as to recommend that responsibility for the Act should be assigned to a minister who is not a proponent of increasing agricultural productivity and consequently a proponent of pesticide use.

On the other hand, it is clear that the pesticide review process involves the weighing of both risks and benefits, and all the departments involved have their particular biases. The three advisor departments all have strong "safety" biases. Agriculture has its productivity bias, but it also has a safety bias with respect to the marketability of residue-free farm products, the protection of pollinators and natural predators of farm pests and the protection of farm water supply quality, On balance, Agriculture seems to be the reasonable choice as decision-maker, but with one proviso -- the Pest Control Products Act should be amended to recognize formally the practice of basing decisions on the advice of the advisory departments.

> IT IS RECOMMENDED that the Pest Control Products Act be amended to provide for product registration based on advice from the Ministers of National Health and Welfare, Environment, and Fisheries and Oceans.

14. LONG RANGE TRANSPORT OF ATMOSPHERIC POLLUTANTS (LRTAP)

14.1 Issue

A decade ago, water quality management meant treatment of municipal and industrial liquid wastes and the regulation of some farm practices to reduce pollution from surface drainage. Little, if any, thought was given to the atmosphere as a source of water pollution. The significance of long range transport of airborne pollutants (LRTAP), or acid rain, only began to come into focus in Canada in the mid 70's with the identification of toxic substances in the Great Lakes and the loss of fish productivity in Scandanavian lakes. The source of the latter problem was traced to sulphur dioxide emissions in the industrialized areas of Great Britain and western Europe.

These findings stimulated research interests in eastern Canada where early studies found evidence of surprisingly acidic rainfalls and spring snow melts, a tentative relationship between increasing water acidity and reduced salmon productivity in several Nova Scotian rivers, and suspicions of reduced forest growth.

More recent research indicated that there are more than 260 million hectares of eastern Canada including thousands of lakes that are susceptible to acid rain damage. These areas have naturally acidic soils with low buffering capability. Signs of stress have been found in many lakes surveyed in Ontario and Québec. At least ten once important salmon rivers in Atlantic Canada no longer support salmon runs; others are under stress.

The problem is compounded by the ability of acid rain to leach toxic metals from soils and exposed bedrock, increasing their concentrations in watercourses. Mercury, cadmium, zinc,

aluminum, arsenic, and others are involved. These may accumulate in the tissues of fish, waterfowl, and water-frequenting mammals, reducing population levels. Contamination levels in fish may also render them dangerous to eat. Heavy metals concentrations in waters used as drinking water sources can also pose human health problems.

The LRTAP issue is not restricted to acid rain that is related to the gaseous emissions of thermal electric plants, the smelting industry and transportation systems. A variety of other dangerous substances reach our watercourses through airborne pathways. It has been estimated, for example, that one tonne of polychlorinated biphenols (PCB's) annually enter Lake Ontario from airborne sources. The pesticide toxaphene has been found in trace amounts in Lake Superior, many hundreds of miles from where it is used.

14.2 Objective

The objective of the LRTAP program as defined by Environment Canada, is to reduce acidic deposition to a level that will protect the health and well-being of man, the health and diversity of species and ecosystems and the sustained use of natural resources for social and economic benefit. The objectives of the aquatic component are to relate airborne emissions to water quality and to determine the effects on aquatic life, water-frequenting birds and animals and human health.

More specifically, sub-objectives directly related to water management and to support the negotiation of control measures with the United States are:

(a) to monitor spatial and temporal trends in water chemistry in relation to atmospheric loading (DOE - IWD);

(b) to quantify pathways and define cause-effect relationships (DOE - IWD);

(c) to assess effects of acidification on the habitat and food of selected wildlife species (DOE - CWS);

(d) to assess the effects of acidification on changes in concentration of some toxic substances in the environment and their effects on wildlife (DOE - CWS);

(e) to develop scientific documentation on the effects of acid rain on fisheries (DFO);

(f) to assess the economic and social costs associated with the deterioration of the fishery resource (DFO);

(g) to preserve genetically valuable fish stocks over the interim period while awaiting effective emission control measures (DFO);

(h) to assess the risks to health posed by airborne pollutants and monitor the influence of abatement programs (NHW);

(i) to negotiate federal-provincial agreements to reduce domestic emissions (DOE); and,

(j) to negotiate Canada-U.S. agreements to reduce emissions (DOE, EA).

14.3 Strategies

Since more than half the acidic pollutants falling in Canada have been traced to U.S. sources, solution to the problem involves two major thrusts -- reducing Canadian emissions and convincing the Americans to take similar action. The domestic control action is required both in its own right

and as a firm demonstration to the U.S. that Canada is serious about the issue and intends to see it solved.

The present U.S. Government has been reluctant to initiate expensive emission control programs. The excuse has been that insufficient evidence has been amassed to demonstrate clear cause and effect relationships between sulphur dioxide emissions and environmental damages. The Canadian strategy must, therefore, include continuance of sophisticated monitoring and research programs to add to the evidence already accumulated, including attention to oxides of nitrogen.

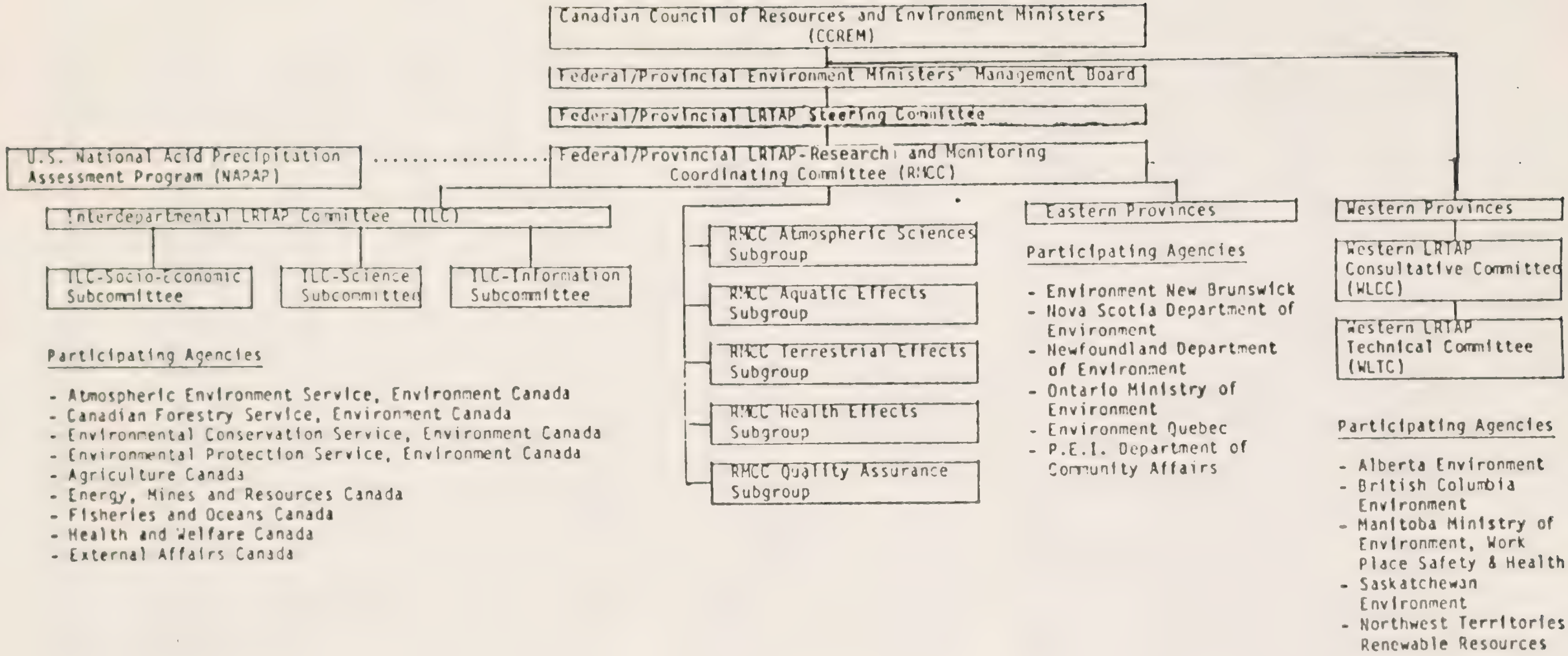
Domestic concerns about acid rain were first focussed by federal-provincial discussions convened under the Canadian Council of Resource and Environment Ministers. Through that forum, a coordinating network was formed to exchange information, coordinate research programs, work towards agreements to reduce domestic emissions and support efforts to encourage the United States to take similar measures.

As shown in Table 14.1, the arrangements include a Federal-Provincial LRTAP Steering Committee, an Acid Rain Research and Monitoring Coordinating Committee and separate working committees for eastern and western provinces. A common federal link among all research and monitoring efforts is Environment Canada's assistant deputy minister, Atmospheric Environment Service, who co-chairs the Research and Monitoring Committee and chairs the eastern and western working groups.

In early February 1985, agreement was reached by ministers to reduce LRTAP emissions to target levels within an agreed time frame. The agreement includes the federal government and all provinces east of Saskatchewan, and provides for reductions of 50 percent of 1980 sulphur dioxide emission levels from power plants and smelters by 1994.

Table 14.1

LRTAP COMMITTEE STRUCTURE



At the federal level, responsibilities for developing LRTAP control strategies rests with Environment Canada's Environmental Protection Service, while the Atmospheric Environment Service is responsible for coordinating federal research and monitoring programs. An Interdepartmental LRTAP Committee (ILC), chaired by the assistant deputy minister, Atmospheric Environment Service while focussing on research and monitoring, is responsible for:

(a) reviewing program plans of participating departments to ensure effective coordination of efforts;

(b) reviewing results of scientific and technical programs to ensure continuing coordination and to assess implications for control strategies;

(c) receiving reports on progress in federal-provincial and international negotiations and revising scientific programs as needed to meet requirements of control strategies;

(d) reviewing and ensuring coordination of interdepartmental public information programs on LRTAP; and,

(e) advising ministers on the above matters as required.

A small LRTAP Liaison Office, reporting to the chairman of the ILC, has been set up to:

(a) provide information and advice to elected officials and senior management on scientific matters and policies arising therefrom relating to Canada-U.S. and federal-provincial negotiations convering transboundary air pollution;

(b) evaluate, coordinate and monitor federal programs; and,

(c) maintain liaison with U.S. and provincial counterparts.

Departments represented on the ILC are Environment; Fisheries and Oceans; National Health and Welfare; Agriculture; Forestry; Energy, Mines and Resources; and External Affairs. Environment's representation includes three sectors of the Department: Atmospheric Environment Service, Environmental Protection Service, and the Environmental Conservation Service. The latter contains the Inland Waters Directorate and Canadian Wildlife Service whose research and monitoring programs contribute to the aquatic component of the acid rain program.

The major aquatic programs of the federal agencies include the following monitoring and research categories:

DOE - IWD monitoring of water quality trends in acidification and metals concentrations including seasonal impacts of spring snow melt; surveys of water chemistry and phytoplankton

watershed studies of susceptible lakes to examine historical trends through sediment core analysis; current trends in water chemistry and biology in relation to atmospheric deposition on calibrated watersheds

modelling to relate atmospheric deposition to aquatic acidification and to attempt prediction of future effects

paleoecological studies to determine historic changes in the acidity of selected lakes

geochemical studies of the behaviour of specific metals in lakes, peatland drainages, etc.

DOE - CWS <u>biological studies</u> to relate the acidification and heavy metal mobilization on waterfowl and water-frequenting animals

DFO - <u>surveys</u> of chemistry and biology in lakes and streams sensitive to acid rain with emphasis on salmon rivers and trout bearing lakes

<u>watershed studies</u> to determine mechanisms and trends of acidification and the related effects on fish and food chain components

<u>biological studies</u> to determine toxic effects of specific levels of acidification and metals concentrations on fish species

<u>remedial studies</u> to develop and test liming techniques to counter acidification and preserve genetic stocks pending controlled reduction of acid rain levels

NHW - <u>assessment</u> of the implications of acidification and metals mobilization on drinking water sources; assessment of acidic waters on eyes of swimmers.

In 1983-84, total federal resources expended on the LRTAP program amounted to some $15,735,000 and 214 person-years. The aquatic component accounted for about 43% of the total. The remainder was made up largely of atmospheric emissions monitoring, inventory, control measure development, and air quality health implication studies.

Estimates of the financial and manpower resources to the aquatic component of the LRTAP program are outlined in Table 14.2.

Table 14.2

FEDERAL LRTAP RESOURCES
Aquatic Component

AGENCY	80-81 $000	80-81 P-Y	81-82 $000	81-82 P-Y	82-83 $000	82-83 P-Y	83-84 $000	83-84 P-Y	84-85 $000	84-85 P-Y
DOE-IWD	255	8.1	570	12.9	1,185	24.5	1,204	25.2	1,192	26.8
DOE-CWS	680	10.2	803	11.2	662	10.5	680	9.5	823	9.3
DFO	2,502	35.0	4,400	48.4	4,539	55.0	4,772	58.1	4,000	54.0
NHW*	22	0.1	38	0.2	44	0.5	51	2.0	27	0.5

* Drinking water component only; aquatic total may be higher.

14.4 Comment

A review of the federal LRTAP research programs was completed early in 1984 by the Royal Society of Canada. General satisfaction was expressed for the aquatic program. Some projects involving experimental acidification of lakes to determine ecological effects were considered to be world leaders.

On the other hand, the Society made a number of observations that were critical:

(a) the program objectives were considered too general to guide the definition of research programs;

(b) some departments had developed strong well-managed programs while others had not;

(c) fiscal funding uncertainties created difficulties for planning, execution and continuity of research;

(d) the aquatic component was inadequately coordinated with the atmospheric component;

(e) review, assessment and synthesis of project results required strengthening; and,

(f) the socio-economic studies were weak.

Each of these criticisms may be traced to the Royal Society's most significant observation. No single agency or individual has been given the authority necessary to make the program operate effectively. The Society recommended that:

> "Overall control over the LRTAP program be sharply increased with authority for funding concentrated in some lead agency."[1]

The multi-faceted nature of the LRTAP problem signals the obsolescence of the traditional natural resource management categories of water, air, forest and agriculture when quality is at issue. It explains the adoption of new interdepartmental approaches based on issues rather than on the management of individual resources. The Interdepartmental Committee on LRTAP, however, is a typical example of the federal government's well-intentioned but less than perfect approach to coordinating its internal affairs. Its tasks are to review programs, effect coordination and advise ministers; but it has no teeth. Its tools, or those of Environment Canada that chairs it, are limited to good will and persuasion.

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[1] Royal Society of Canada, 1984. Long-Range Transport of Airborne Pollutants in North America: A Peer Review of Canadian Federal Research. (p.12)

In the end, each minister is sovereign when selecting among priorities within his mandate and when seeking supplementary resources to participate in new initiatives like the LRTAP program. The final results are often something less than ideal, as the Royal Society's observations attest. A well-balanced LRTAP program has yet to emerge.

During the course of the current review, the same basic problem identified by the Royal Society became apparent. Concerns were expressed over the relative distribution of supplementary resources available to the research programs of the various agencies. While some excellent cooperation exists, there remains a need for a more comprehensive and integrated federal program.

In some cases, there has been uncertainty of continuing funding from year to year. In one situation, Fisheries and Oceans did not obtain required resources until well into the fiscal year in which they were required.

It is time to break away from tradition and adopt a more business-like approach. Responsibility centres must be given the authority to achieve what is expected of them. Once the Government has identified a new priority issue with interdepartmental dimensions that is amenable to reasonably short-term solution, overall responsibility for it should be assigned to one minister whose authority should extend to comprehensive problem definition, program development and the control of supplementary resources that may be required by various departments to contribute to the program. Assignment of authority in this fashion would, of course, extend down to interdepartmental committees advising the responsible minister. While a committee's success would remain largely dependent on good will and persuasion, a chairman's control over supplementary resources would go a long way in ensuring the desired degree of cooperation.

The lead department would, in effect, be able to purchase the required extra services from other departments that could not supply them through their regular budgets.

While acid rain may affect health and the management of many resources, Environment Canada remains the most appropriate centre for federal responsibility. The Department is responsible for developing the federal government's pollution control atrategies and carries the federal government's responsibilities for atmospheric, water and wildlife management.

> IT IS RECOMMENDED that Environment Canada's lead role respecting LRTAP be redefined to encompass authority for:
>
> (a) developing comprehensive research and technical plans that integrate the programs and resources of all departments,
>
> (b) seeking supplementary funding and staff that may be required to implement the identified program needs, and
>
> (c) allocating supplementary funding and staff that may be made available to implement approved programs.

The Minister of Environment would be identified as the Minister responsible for dealing with the LRTAP problem, and the Interdepartmental Committee on LRTAP would report to and advise that Minister.

To assist the Chairman of the Interdepartmental Committee:

> IT IS RECOMMENDED that the Interdepartmental Liaison Office on LRTAP be redesignated as the LRTAP Secretariat or Office, reporting to the Chairman and drawing its coordinating authority from his.

15. CONCLUDING COMMENT

15. CONCLUDING COMMENT

Briefs submitted to the Inquiry on Federal Water Policy identified both current critical problems and anticipated ominous issues. The first group are primarily related to water quality, led by toxic chemicals and acid rain. The second group centre on anticipated water shortages from the combined effects of increasing consumptive uses and climatic change. It raises questions concerning conservation practices, the propriety of supporting new irrigation schemes in the west, the need for understanding with the U.S. to limit and share consumptive uses of the Great Lakes, and the specter of massive diversions of water from one basin to another.

The topic selection and recommendations in this review have been designed to address these two categories of need, the preparations necessary to deal with anticipated problems and the resolution of existing priority issues. Thus the focus on maintaining and strengthening, planning and intergovernmental arrangements on the one hand and taking action on toxic substances, acid rain and the Great Lakes program on the other.

Unfortunately, it has not been possible to tally up the totals of federal funds and personnel dedicated to water management. Fisheries and Oceans could not differentiate resources assigned to fish habitat management from those dedicated to fish. The Environmental Protection Service of Environment Canada find it difficult to sub-divide resources applied to a particular issue, such as toxic chemicals control, into water, air or land management activities. Such statistics that are available are given in Appendices I-IV.

Environment Canada is the federal government's principal water manager. In 1984-85, the Inland Waters Directorate budgeted for about \$112 million with 1,056 person-years of employment. If one may assume that about three-quarters of the Environmental Protection Service's effort goes toward water quality, then its 1984-85 figure would be \$56 million and 575 person-years. The Canadian Wildlife Service's important contributions to the toxic substances and acid rain programs were expected to amount to some \$1.5 million and 20 person-years. In total then, Environment Canada devoted in the order of \$170 million and 1,650 person-years to water management in Canada.

National Health and Welfare dedicated approximately \$4.5 million and 71 person-years to programs related directly to water quality.

Agriculture Canada budgeted \$2.5 million and 47 person-years to water research for agriculture.

The total expenditures of these management oriented agencies for 1984-85 was about \$177 million and 1,770 person-years.

These figures do not include resources budgeted for by developer/user agencies such as Regional Industrial Expansion or PFRA. PFRA, for example, has 1984-85 estimates for water development operations of some \$42 million and 660 person-years. A portion of the \$42 million was provided under economic regional development agreements.

In an unclear jurisdictional situation, Environment Canada has found a reasonable way to work in cooperation with the provinces to the advantage of both. This is demonstrated through agreements for water quantity and quality networks.

the flood damage reduction program, the Great Lakes Water Quality program, and to a lesser degree, through the accords on environmental protection.

Considerably more attention must be dedicated to current water quality issues. In particular, it is essential that the Environmental Contaminants Act be amended to provide for an efficient registration system of potentially toxic substances, so that their use may be controlled or prevented. The International Joint Commission was blunt in its recommendation to Canada and the U.S. in 1980 that: "... the production, sale, transport or use of persistent synthetic organic compounds with known highly toxic effects whose use will result in their entry into the environment be prohibited". Canada is not acting quickly enough.

In light of the restricted resources available to both the federal and provincial governments, every opportunity should be explored for closer federal-provincial collaboration on problems of mutual concern. Cost-sharing and work-sharing agreements on specific water quality issues might be modelled after the water monitoring agreements already in place.

Fisheries and Oceans might consider the same approach to extricate itself from the dilemna of how to implement its fish habitat policy, particularly in those provinces that administer the Fisheries Act.

Within the federal government, Environment Canada must clarify for itself, and other departments, first what its role should be. If it is to be what it should be, the quasi-water manager, then its role is to establish, carry out and coordinate the policies and programs of other federal agencies related to water research, planning,

monitoring, allocation and regulation. It should not become involved as a water resource developer as this would place it in a serious conflict of interest situation of judging on its own water use proposals.

The relationship of Environment Canada to those federal agencies that are the proponents of water development needs particular clarification. If a development agency desires a regional assessment of the development potential of water for example, it should turn to Environment Canada to develop the appropriate arrangements with the provinces involved. With respect to individual development proposals, however, the situation is more complex. In its quasi-water allocation role, Environment Canada can do two things. First, it can ensure that the socio-economic assessments of development proposals are performed to meet a set of formally established criteria. Second, it can advise on the relative merits or implications of a proposal, that is to say, for example, it could advise that an irrigation scheme in Alberta might be less productive than allowing the water to run through a hydroelectric plant downstream. The decision, however, would and should remain with the province in cooperation with the federal development agency involved.

From time to time, as new priority issues evolve, governments find it useful to re-organize their bureaucracies. The position put forward here is that whatever organization is contemplated, it is important to maintain a separation between the water management agemcy and the proponents of development.

Water prevades the interests of so many agencies that perhaps the real challenge is to find and adopt a more businesslike approach to government -- one that includes greater delegation of authority and responsibility to individual ministers.

Once a priority issue amenable to short-run solution has been identified, it should be assigned to a minister along with enough interdepartmental clout to effect a solution. The clout should include whatever supplementary resources are to be assigned to the problem.

APPENDIX I

INLAND WATERS DIRECTORATE

RESOURCES BY PROGRAM

	82-83		83-84		84-85	
	$000	P/Y	$000	P/Y	$000	P/Y
1.1	10913.7	160.8	18102.7	143.0	32065.0	150.2
1.2	12005.0	37.0	5451.7	38.8	3270.1	38.5
1.3	7522.0	62.8	9666.8	86.2	10718.0	106.4
1.4	29700.6	359.9	34047.8	343.2	36418.7	359.2
1.5	12447.0	193.2	12161.9	183.7	12953.7	187.7
1.6	44132.3	126.5	29143.4	126.1	8256.3	107.4
4.1	4021.9	67.1	4201.0	65.9	4886.7	68.1
4.2	4473.2	29.6	2912.1	28.6	2271.1	25.2
4.3	786.0	13.2	1139.0	14.6	1174.7	13.8
TOTALS	126001.7	1050.0	116826.4	1030.0	112014.3	1056.0

1.1 Canada-U.S. and Interjurisdictional
1.2 Flood Damage Reduction
1.3 Water Quality Data
1.4 Water Quantity Data
1.5 Research
1.6 Management and Administration
4.1 Toxic Chemicals
4.2 Long Range Transport and Air Pollutants
4.3 Environmental Assessment

APPENDIX 1

INLAND WATERS DIRECTORATE
ENVIRONMENT CANADA

RESOURCES BY PROGRAM

Headquarters (Hull)

CODE	82-83		83-84		84-85	
	$,000.	P/Y	$,000.	P/Y	$,000.	P/Y
1.1	2709.2	45.6	13565.8	51.9	26663.6	55.1
1.2	338.4	11.9	549.0	11.9	500.0	11.0
1.3	712.3	13.9	2760.2	35.6	3967.4	59.6
1.4	1985.5	32.0	2224.8	25.2	3271.3	32.2
1.5	432.1	3.0	489.6	3.0	871.7	5.0
1.6	37439.7*	39.0	22436.5*	38.0	1682.0	28.0
4.1	22.0	0.5	207.3	5.4	207.3	5.4
4.2	53.5	1.0	114.0	1.7	123.6	2.0
4.3	44.5	0.6	6.0	0.4	24.7	0.4
TOTALS	43737.2	147.5	42353.2	173.1	37311.6	198.7

*contains Great Lakes sewage treatment grants.

Research Institutes

1.1	759.0	19.0	843.0	19.0	1050.0	22.0
1.2	--	--	--	--	--	--
1.3	275.0	5.0	316.0	6.0	324.0	5.0
1.4	125.0	3.0	146.0	3.0	154.0	3.0
1.5	10786.0	170.7	10447.0	162.0	10584.0	164.0
1.6	4202.0	51.0	4098.0	52.0	4056.0	47.9
4.1	2219.0	46.0	2500.0	48.7	2797.0	47.8
4.2	991.0	18.3	917.0	18.0	694.0	15.0
4.3	48.0	1.0	100.0	2.3	107.0	2.3
TOTALS	19405.0	314.0	19367.0	311.0	19766.0	307.0

Atlantic Region

1.1	391.5	10.1	585.6	13.6	620.9	13.9
1.2	251.5	6.5	250.9	5.3	291.3	6.2
1.3	508.0	11.7	543.1	11.4	472.8	9.4
1.4	1545.9	31.6	1609.3	30.8	1873.9	31.8
1.5	11.3	0.2	8.6	0.2	9.0	0.2
1.6	309.3	8.0	283.2	7.0	295.3	7.0
4.1	220.9	5.7	158.7	3.7	254.0	5.7
4.2	174.9	4.5	193.0	4.5	200.6	4.5
4.3	27.3	0.7	68.5	1.6	26.7	0.6
TOTALS	3440.6	79.0	3700.9	78.1	4044.5	79.3

Québec Region

CODE	82-83 $,000.	82-83 P/Y	83-84 $,000.	83-84 P/Y	84-85 $,000.	84-85 P/Y
1.1	536.0	1.3	443.0	1.2	866.0	1.9
1.2	5640.0	1.3	3776.0	2.3	1071.0	2.2
1.3	4396.0	9.5	4427.0	8.5	4485.0	8.7
1.4	10761.0	5.5	13043.0	5.5	13383.0	6.6
1.5	--	--	--	--	--	--
1.6	933.0	2.3	770.0	2.0	1020.0	2.0
4.1	1125.0	1.3	839.0	1.2	1129.0	1.2
4.2	3169.0	3.8	1665.0	3.7	1230.0	3.0
4.3	387.0	0.8	609.0	1.6	577.0	1.4
TOTALS	26947.0	25.8	25572.0	26.0	23761.0	27.0

Ontario Region

CODE	82-83 $,000.	82-83 P/Y	83-84 $,000.	83-84 P/Y	84-85 $,000.	84-85 P/Y
1.1	3233.5	46.6	1101.8*	21.4*	1225.5	22.8
1.2	872.9	3.7	191.6	4.8	226.9	4.8
1.3	--	--	--	--	--	--
1.4	2319.4	46.5	2421.9	47.1	2718.7	49.0
1.5	--	--	--	--	--	--
1.6	336.8	5.0	482.2	7.6	236.8	3.8
4.1	172.9	4.0	140.2	2.9	216.8	4.0
4.2	42.4	1.0	23.1	0.7	22.9	0.7
4.3	177.1	3.7	154.7	3.0	176.6	3.4
TOTALS	7155.0	110.5	4515.5	87.5	4824.2	88.5

*Decrease due to centralization of water quality laboratory services to HQ.

West and North Region

CODE	82-83 $,000.	82-83 P/Y	83-84 $,000.	83-84 P/Y	84-85 $,000.	84-85 P/Y
1.1	1880.5	25.2	1130.4	25.1	1192.5	24.5
1.2	870.6	7.9	347.0	6.6	326.3	6.3
1.3	907.6	11.8	1008.0	14.1	758.5	12.6
1.4	8613.4	162.8	9675.9	154.6	9792.7	158.6
1.5	446.5	7.4	509.1	7.0	468.3	7.0
1.6	506.9	13.4	521.4	10.5	525.2	10.0
4.1	197.5	6.2	88.5	1.0	107.5	1.0
4.2	--	--	--	--	--	--
4.3	95.5	3.4	158.1	3.0	153.2	3.0
TOTALS	13518.5	238.1	13438.4	222.0	13324.2	223.0

Pacific and Yukon Regions

CODE	82-83 $,000.	82-83 P/Y	83-84 $,000.	83-84 P/Y	84-85 $,000.	84-85 P/Y
1.1	1404.0	13.0	433.1	10.8	556.5	10.5
1.2	4026.6	5.7	337.2	7.9	354.6	8.0
1.3	723.1	10.9	612.5	10.6	710.3	11.1
1.4	4350.4	78.5	4924.9	77.0	5225.1	78.0
1.5	779.1	11.9	707.6	11.5	720.7	11.5
1.6	314.6	7.8	552.1	9.0	441.0	8.7
4.1	64.6	3.4	158.3	3.0	175.1	3.0
4.2	--	--	--	--	--	--
4.3	6.6	3.0	105.3	2.7	109.5	2.7
TOTALS	11669.0	134.2	7831.0	132.5	8292.8	133.5

APPENDIX 2

ENVIRONMENTAL PROTECTION SERVICE
ENVIRONMENT CANADA
RESOURCES BY PROGRAM

1983-84

	1 $	2 $	3 $	4 $	5 $	6 $	7 $	TOTAL $
Headquarters	9,581,342	3,494,250	1,771,131	1,479,498	4,681,900	2,111,158	12,406,107	35,525,386
Regions:								
Atlantic	737,023	220,029	668,263	295,765	1,552,379	556,914	887,543	4,917,826
Québec	1,193,583	75,246	473,100	218,757	393,951	324,205	628,793	3,307,635
Ontario	1,194,227	58,768	144,021	58,824	360,372	647,675	10,326	2,474,213
W & N	617,254	156,646	1,239,290	469,067	1,390,353	720,472	302,499	4,895,581
Pacific	1,313,818	37,214	113,732	538,226	1,215,995	756,220	925,930	4,901,135
TOTAL(regions)	5,055,905	547,903	2,638,406	1,580,649	4,913,050	3,005,486	2,755,091	20,496,391
GRAND TOTAL	14,637,247	4,042,153	4,409,537	3,060,047	9,594,950	5,116,644	15,161,198	56,021,777
PERSON YEARS	99	36	631					766

CODE
1 Corporate Guidance
2 Priority Issues Directorate
3 Assessment & Remedial Measures
4 Commercial Chemicals Management
5 Control of Threats
6 Waste Management
7 Technical Services

1982-83

	1 $	2 $	3 $	4 $	5 $	6 $	7 $	8 $	TOTAL $
Headquarters	7,115,394	7,462,090	3,286,802	1,187,216	2,871,445	1,865,640	701,732	5,858,969	30,349,288
Regions:									
Atlantic	123,615	440,990	120,935	91,871	44,218	190,996	--	3,241,051	4,253,676
Québec	236,177	880,685	174,839	229,003	155,560	336,707	--	949,678	2,962,649
Ontario	94,900	198,858	28,896	102,181	170,310	30,015	260,799	1,429,077	2,315,036
Northwest	281,159	1,558,579	370,044	690,469	131,341	370,974	--	731,399	4,133,965
Pacific	187,005	1,952,794	231,890	329,025	39,852	311,693	--	1,321,553	4,373,812
TOTAL(regions)	922,856	5,031,906	926,604	1,442,549	541,281	1,240,385	260,799	7,672,758	18,039,138
GRAND TOTAL	8,038,250	12,493,996	4,213,406	2,629,765	3,412,726	3,106,025	962,531	13,531,727	48,388,426
PERSON YEARS	153	240	48	66	40	59	8	151	765

Code
1 Air Pollution
2 Water Pollution
3 Environmental Emergencies
4 Federal Activities
5 Waste Management
6 Contaminants Control
7 Toxic Chemical
8 Management and Common Support

NOTE (1) Source - Statement #60001 on Microfiche #135 for p.16, 1982-1983.

1981-82

	1 $	2 $	3 $	4 $	5 $	6 $	7 $	8 $	TOTAL $
HQ	16,161,208	1,969,291	2,372,237	221,251	784,242	1,699,027	914,033	4,708,486	28,829,775
Regions:									
Atlantic	2,878,826	392,559	66,032	104,667	68,501	34,028	6,425	145,924	3,696,962
Québec	250,323	848,315	149,122	172,549	171,765	83,663	--	435,300	2,111,037
Ontario	1,315,598	173,065	33,954	47,835	50,895	70,402	536	238,914	1,931,199
Northwest	2,364,523	354,152	100,723	239,868	72,264	28,148	9,303	393,635	3,562,616
Pacific	1,970,923	599,087	109,643	50,407	62,965	16,594	--	938,790	3,748,409
TOTAL REGION	8,780,193	2,367,178	459,474	615,326	426,390	232,835	16,264	2,152,563	15,050,223
GRAND TOTAL	24,941,401	4,336,469	2,831,711	836,577	1,210,632	1,931,862	930,297	6,861,049	43,879,998
PERSON YEARS	159	233	46	78	64	31	--	140	751

Code
1 Air Pollution
2 Water Pollution
3 Environmental Emergencies
4 Federal Activities
5 Waste Management
6 Contaminants Control
7 Toxic Chemical
8 Management and Common Support

NOTE: 1) Source - Statement #60001 P.15 Microfiches 124 & 125

1980-81

	1	2	3	4	5	6	7	8	9	TOTAL
	$	$	$	$	$	$	$	$	$	$
HQ	75,202	9,805,732	5,812,086	2,997,558	2,658,274	673,059	794,558	715,723	1,650,913	25,183,105
Regions:										
Atlantic	--	2,589,457	120,524	485,715	68,186	72,011	76,520	1,546	18,604	3,423,563
Québec	--	846,745	148,742	452,533	70,113	146,911	90,075	2,412	36,455	1,793,986
Ontario	--	1,218,220	37,555	129,560	33,778	95,278	94,053	--	61,582	1,670,026
Northwest	--	2,387,993	27,333	367,023	77,263	133,960	32,850	--	51,180	3,077,602
Pacific	--	2,599,878	21,632	380,214	52,830	74,590	47,316	--	16,688	3,193,148
TOTAL REGIONS	—	9,633,293	355,786	1,815,045	302,170	522,750	340,814	3,958	184,509	13,158,325
GRAND TOTAL	75,202	19,439,025	6,167,872	4,812,603	2,960,444	1,195,809	1,135,372	719,681	1,835,422	38,341,430
PERSON YEARS	-	140	155	233	46	78	64	-	31	747

Code
1 Toxic Chemical
2 Management & Common Support
3 Air Pollution
4 Water Pollution
5 Enviornmental Emergencies
6 Federal Activities
7 Contaminants Control
8 Environmental Contaminants Control Fund
9 Waste Management

NOTE: 1) Source - Statement #60001 on Microfiche #100 for p.15, 1980/81

APPENDIX III

HEALTH PROTECTION BRANCH
NATIONAL HEALTH AND WELFARE

RESOURCES BY PROGRAM

	82-83		83-84		84-85	
	$000	P/Y	$000	P/Y	$000	P/Y
Drinking Water	723.0	8.7	1007.0	11.6	752.0	10.2
Acid Rain (Drinking water component)	44.0	0.5	51.0	2.0	27.0	0.5
Environmental Contaminants	1750.0	31.5	2547.0	31.9	2562.0	31.6
Great Lakes	200.0	N.A.	200.0	N.A.	200.0	N.A.
Pesticides*	674.0	11.5	990.0	17.0	1132.0	28.8

*Relates to health and all resources.

APPENDIX IV*

FISHERIES AND OCEANS
EXPENDITURES BY REGION

FISHERIES MANAGEMENT (\$000's) Category a)

REGION	80/81	81/82	82/83	83/84	84/85
Newfoundland	1,855 30	2,204 49	2,744 65	2,619 62	2,912 66
Scotia/Fundy	3,703	5,095	4,501	4,368	4,217
Gulf	- Region nonexistent -		2,264	2,770	2,672
Ontario	1,954	2,224	2,973	2,965	2,768
Western	6,079	6,691	6,412	6,950	8,331
Pacific	3,048	4,002	4,616	5,657	6,210
Headquarters	226	295	394	482	499
GRAND TOTAL	16,895	20,560	23,969	25,873	27,675

a) Expenditures in the freshwater and anadromous areas of the Fisheries Research Branches in all Fisheries Management regions (also includes aquaculture, stock and habitat enhancement and rehabilitation).

*All figures provided by Fisheries and Oceans -- no catagorization possible into "water" and "fish".

APPENDIX IV

FISHERIES MANAGEMENT (\$000's) Category b)

REGION	80/81	81/82	82/83	83/84	84/85
Newfoundland	84 15	116 23	97 24	147 22	160 19
Scotia/Fundy	435	451	189	179	166
Gulf	- Region nonexistent -		1,126	1,301	1,333
Ontario	1,949	1,942	2,219	2,575	2,763
Western	6,363	6,681	11,159	11,430	11,591
Pacific	46,543	51,684	50,194	53,470	52,007
Headquarters					
GRAND TOTAL	55,389	60,897	65,008	69,124	68,039

b) Expenditures in the freshwater and anadromous areas of the Fisheries Operations Branches in all Fisheries Management regions (also includes aquaculture, stock and habitat enhancement and rehabilitation).

APPENDIX IV

FISHERIES MANAGEMENT
($000's)

Category e)

REGION	80/81	81/82	82/83	83/84	84/85
Newfoundland					
Scotia/Fundy	-	2	16	27	5
Gulf	- Region nonexistent -				
Quebec					
Ontario	3,862	3,729	4,733	17,607	20,083
Western	1,026	700	971	807	715
Pacific	128	16	101	461	63
Headquarters					
GRAND TOTAL	5,016	4,447	5,821	18,902	20,866

e) Expenditures on the construction and maintenance of harbours in freshwater made by Small Craft Harbours.

FISHERIES MANAGEMENT ($000's) Category f)

REGION	80/81	81/82	82/83	83/84	84/85
Newfoundland					
Scotia/Fundy					
Gulf	- Region nonexistent -				
Quebec					
Ontario					
Western	-	-	-	-	420
Pacific	11,446	12,326	18,321	23,619	20,427
Headquarters					
GRAND TOTAL	11,446	12,326	18,321	23,619	20,847

f) Other - expenditures in the freshwater and anadromous areas in Support Services Branches including ships.

OCEAN SCIENCE & SURVEYS
($000's)

	Category c)					Category d)				
REGION	80/81	81/82	82/83	83/84	84/85	80/81	81/82	82/83	83/84	84/85
ATLANTIC	10	10	10	10	10	312	312	442	526	526
QUEBEC	705	180	840	364	560	-	54	46	53	56
CENTRAL	7000	7000	7000	7000	7000					
HQ	410	420	450	550	600					
PACIFIC	135	89	87	69	214					
GRAND TOTAL	8,260	7,699	8,387	7,993	8,384	312	366	488	579	582
						Category f)				
ATLANTIC						590	621	621	621	621
QUEBEC										
CENTRAL										
HQ										
PACIFIC						90	98	90	115	230
GRAND TOTAL						680	719	711	736	851

c) Expenditures related to freshwater charting made by Oceans Science and Surveys.

d) Expenditures related to freshwater regulation and chemical hazards (also includes acid rain and toxic chemicals) made by Ocean Science and Surveys.

f) Other - expenditures in the freshwater and anadromous areas in Support Services Branches including ships.

STUDY TERMS OF REFERENCE

Ojectives:

The objectives of this project are to describe the administration of water resources by the federal government; and to evaluate the effectiveness of federal water administration in relation to jurisdiction, to various policies and programs, and to their coordination.

Tasks:

1. In consultation with federal officials, determine the mandate of each agency against its legislative base, and the degree to which it shares its responsibilities with other federal agencies and with other jurisdictions.

2. For each agency, review and assess the adequacy/appropriateness of its (a) legislation, (b) policies, (c) programs, and (d) financial and human resources, in relation both to agency mandate and to current/emerging issues of water management. (To what degree have these factors changed in the last 5 years? What further changes are planned?)

3. Analyze the formal and informal mechanisms which have evolved to effect coordination of federal water programs, and to enhance cooperation with provinces.

4. Recommend appropriate measures for improving the effectiveness of federal water administration, including but not limited to legislative, program and organizational change.

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Inquiry on Federal Water Policy

Enquête sur la politique fédérale relative aux eaux

Research Papers

Documents de recherche

WATER RESOURCES RESEARCH IN CANADA: ISSUES AND OPPORTUNITIES

by

Bruce Mitchell and Edward McBean

Canada

Inquiry on Federal Water Policy
Research Paper # 16

WATER RESOURCES RESEARCH IN CANADA: ISSUES AND OPPORTUNITIES

by

Bruce Mitchell and Edward McBean

Bruce Mitchell is Professor of Geography and Edward McBean is Professor of Civil Engineering at the University of Waterloo, Ontario

April 1985

This research paper was cosponsored by the Science Council of Canada. The Science Council is considering publication of the paper at a later date.

THE INQUIRY ON FEDERAL WATER POLICY

The Inquiry on Federal Water Policy was appointed by the federal Minister of the Environment in January of 1984 under the authority of the Canada Water Act. The members were Peter H. Pearse, chairman; Françoise Bertrand, member; and James W. MacLaren, member. The Inquiry was required by its terms of reference to review matters of water policy and management within federal jurisdiction and to make recommendations.

This document is one of a series of research papers commissioned by the Inquiry to advance its investigation. The views and conclusions expressed in the research papers are those of the authors. Copies of research papers and information on the series may be obtained by writing to the Enquiry Centre, Environment Canada, Ottawa, Ontario K1A 0H3.

Frank Quinn

Frank Quinn
Director of Research

Abstract

This report focuses on three objectives: to provide an inventory of water research activities in Canada, to identify future research needs and priorities and to evaluate federal research programs regarding their capacity to respond to changing priorities for water resources research, coordination, and management in Canada. In addressing these objectives, the reported findings include evidence of approximately $55.8 million being spent on water resources research in Canada in 1983, with the federal government being the dominant participant, providing 73 percent of the funds and expending 51 percent of the funds. This funding level represents an effective 25 percent decrease since 1979.

Extensive discussion is presented on the current structure and organization of water resources research efforts in Canada, problems identified during the information collection effort and recommendations made on possible approaches to improve the situation.

Résumé

Ce rapport poursuit trois objectifs: fournir un inventaire des activités de recherche dans le domaine hydrique au Canada, identifier les besoins et priorités futurs et évaluer les programmes de recherche fédéraux en fonction de leur habilité à répondre aux priorités changeantes dans le domaine de la recherche, de la coordination et de gestion des ressources en eau au Canada.

Les résultats rapportés indiquent qu'environ $55.8 millions ont été consacrés à la recherche reliée à la ressource eau en 1983. Le gouvernement fédéral a été le principal bailleur de fonds fournissant 73 pourcent de ceux-ci et en dépensant lui-même 51 pourcent. Ce niveau de financement représente une diminution réelle de 25 pourcent par rapport à 1979.

Une discussion détaillée de la structure et de l'organisation actuelles de la recherche reliée à la ressource eau au Canada, des problèmes qui ont été identifiés durant la période de collecte d'information et des recommandations qui sont faites sur les stratégies possibles afin d'améliorer la situation est présentée.

Water resources is a combination of knowledge, understanding and guesswork. Research enlarges the first two.

It only takes one pellet to hit a duck but a shotgun is still used. The role of the research manager is to ensure the gun is pointed in the right direction.

Research is like the sparkplug in an engine. It isn't the sparkplug alone that ensures forward motion but without the sparkplug it is unlikely there will be motion in any direction.

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EXECUTIVE SUMMARY

This report has three objectives. The first is to provide an inventory of water research activities in Canada. Attention focuses upon current arrangements to facilitate water research and upon the levels and nature of research activity. The second is to identify future research needs and priorities. The third is to evaluate federal research programs regarding their capacity to respond to changing priorities for water resources research, coordination, and management in Canada.

About one-quarter of the 301 briefs submitted to the Inquiry on Federal Water Policy explicitly addressed the matter of water resources research. Strong support was expressed from organizations and individuals from across the country for an active and vigorous role in water resources research by the federal government. It repeatedly has been argued that the federal government has roles both as a 'doer' and as 'facilitator' in research, and that ongoing and newly emerging problems require a continued and increased level of research effort.

The federal government has recognized that it does have a role in water resources research. In a 1978 policy statement, the government noted that it had a general mandate for research and identified the activities which it would pursue. In addition, two reviews of water resources research have been conducted. In 1966, the Science Council of Canada organized a detailed review. In 1979, Environment Canada held a second review. This report is based on a third review focused upon 1983. This third review is co-sponsored by the Science Council of Canada and the Inquiry on Federal Water Policy.

With regard to current arrangements for water resources research, the outstanding feature is the large number of participants distributed among the federal and provincial governments, the universities and the private sector. However, the federal government is the dominant participant, and in 1983 it provided 73 percent of the funds and spent 51 percent of the funds for water resources research.

The Inland Waters Directorate of Environment Canada is the lead federal agency. In the 1984-1985 estimates, the Inland Waters Directorate allocated $22 million or 2-1/2% of the operational budget of Environment Canada to water resources research. In contrast, during 1983 it is estimated that some $55.8 million was spent on water resources research in Canada.

Despite its dominant role, the federal research effort is not a homogeneous and sharply coordinated set of activities. Within the federal government water research is also pursued by Fisheries and Oceans, Agriculture, Health and Welfare, Energy, Mines and Resources, Transport and the National Research Council. Given the large number of federal line agencies involved in water resources research, a need exists to achieve better coordination. Existing mechanisms for coordination are inadequate either because they are too narrowly focused (NRC Associate Committee on Hydrology), do not have enough of a research focus (Interdepartmental Committee on Water), or do not incorporate enough of the key agencies (Canada Centre for Inland Waters).

Regarding level of effort, Canada generally has a record of providing only modest support for research of most kinds. For example, research and development expenditures in Canada have ranged from .95 to 1.24 of GNP whereas many industrialized countries allocate from 2 to 3 percent. Expressed in 1983 dollars, Canada spent $29.6 million in 1966, $75.4 million in 1979, and $55.8 million in 1983 on water resources research. Thus, between 1979 and 1983 there has been a decrease by 25 percent of funds allocated to water resources research.

The Water Resources Research Support Program through which the federal government provides research funds to universities illustrates the nature of some of the cutbacks. In 1979 the funds for that program were reduced from $1 million annually to $250,000 annually. With inflation considered, the actual purchasing power of the $250,000 has been steadily eroded.

Water quality has received the largest proportion of funding over the years, receiving 30 percent in 1966, 40 percent in 1979, and 53 percent in 1983. Over the same period, there has been a substantial decrease in funds allocated to research dealing with the water cycle, dropping from 47 percent in 1966 to 28 percent in 1983. Throughout, the research effort has been concentrated in central Canada with about 70 percent of the activity located in Ontario and Quebec.

During the public hearings held by the Inquiry on Federal Water Policy, a broad array of research needs was identified. These needs ranged from general concerns with pollution, flooding and water supply, to very specific concerns such as farm-related contaminants into water bodies, peatland water resources, river ice processes, estuary hydrodynamics to freshwater in the boreal plains. In this study, an attempt has been made to identify those needs which are of national significance and therefore of concern to the federal government.

Inventory and monitoring programs exist, but there still is not an adequate descriptive understanding of water resources in Canada. Initiatives in this area to upgrade descriptive understanding must be pursued in consultation and cooperation with the provinces.

Functional knowledge also is poor in many areas. Groundwater deserves more attention. Water diversions or transfers deserve more research, especially regarding their ecological, economic and social impacts. Water quality issues have been and will continue to be important. Wastewater treatment, disposal of toxic wastes and acid rain all require improved understanding. With over 200 communities facing potential flood damages, research is needed to determine adjustment strategies which combine structural and nonstructural responses. Water supply can be a constraint on regional economic development both in urban-centered and rural areas. Attention is needed to develop strategies which combine both supply and demand management methods. Finally, since so many water problems have their causes in adjacent resource complexes, more research should be devoted to integrating water problems with those associated with adjacent land and other resources.

Research needs also can be related to thematic concerns. Efficiency of water use deserves more attention, especially regarding domestic, industrial and agricultural uses. The impacts of water-related development need more research, especially regarding ecological and social aspects not amenable to measurement in monetary terms. Since there usually are risk and uncertainty associated with water management and development decisions, improved methods are needed to identify and explore the trade-offs among benefits, costs and risk elements. And, since management decisions often must accommodate different and conflicting values, more research focused upon conflict resolution would be appropriate.

During the Inquiry hearings, a frequent call was made for more social science research activity. With the cutback in the Water Resources Research Support Program, it has been argued that social scientists should seek funding through the Social Sciences and Humanities Research Council of Canada. However, the prospects for major new initiatives in the social sciences regarding water research are not good when the funding available from the major granting agency is considered. The budget change (net inflation) between 1979-80 and 1983-84 was 57 percent for the Natural Sciences and Engineering Research Council, but only 5 percent for the Social Sciences and Humanities Research Council. Nevertheless, if more social science research were to be developed, in addition to those fields already identified key areas would be policy and planning analysis, and institutional arrangements.

Another type of activity needing support is research which integrates natural science, engineering and social science research. Existing funding organizations do not easily handle research proposals which cut across disciplinary or professional boundaries. A systematic review of policies and procedures used by the major funding agencies to deal with interdisciplinary research is needed, as researchers have expressed considerable frustration and disappointment with current arrangements.

Several findings and conclusions emerge regarding the capacity of federal research programs to respond to changing priorities, coordination and management. Given the number and array of research activity in Canada, more systematic coordination of the water research effort is needed. Formation of a National Water Research Committee would help to minimize duplication of facilities and effort across the country, ensure a balance between national and regional research needs, facilitate communication within the research community, and relate research activity to management needs. Such a Committee should have members from the federal and provincial governments, the universities and the private sector who also could represent the different regions of the country. The Committee would have to be allocated sufficient funds and authority so that it could influence research activity.

A National Water Research Committee would provide a mechanism to develop a national strategy for water research. For the federal perspective to be incorporated into a national strategy, a Federal Committee for Water Resources Research should be established so that federal ideas and efforts in this field can be integrated. At the

moment, such integration and coordination of federal water resources research does not appear to occur in any systematic and ongoing fashion.

Centralization of research has provided scale economies as well as minimum critical masses of investigators, both of which are positive features. At the same time there has been a real cost when regions without one of the centralized research facilities have their water problems ignored or neglected by researchers. To receive the benefits of centralization and still respond to regional research needs, the use of smaller regional research centres linked to the centralized national research institutes offer potential. Atlantic Canada and British Columbia should be priority areas for regional research centres.

To encourage anticipatory or 'blue sky' research, the National Water Research Committee, the national institutes, the regional centres and the Water Resources Research Support Program should allocate a portion of their research budgets to innovative and unrestricted study for which it is recognized from the outset the likelihood of immediate and positive results is low. However, in this way support will be provided for the type of research which might lead to the really major breakthrough. A portion of the research budgets also should be dedicated to supporting research which is interdisciplinary in nature since the traditional funding agencies have difficulty in accommodating such work.

In time of restraint, with few new research scientists being hired and limited mobility for scientists already on staff, attention must be given to training and education. If the federal government is serious about developing expertise in water resources research in Canada, then sufficient resources must be allocated either to hire new staff, facilitate participation in professional meetings or accommodate sabbaticals or other forms of exchanges by federal investigators with their counterparts in other institutions.

ACKNOWLEDGEMENTS

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Appreciation is also given to the Inquiry on Federal Water Policy and to the Science Council of Canada, for financial support which allowed the study to be completed.

Chapter 1

INTRODUCTION

1.1 THE ROLE OF THE FEDERAL GOVERNMENT IN WATER RESOURCES RESEARCH

"...there is a very definite need for research which is of national significance, and as such, the federal government must play a dominant role" (Canadian Water Resources Association, 1984, 16). "The Federal government should continue and expand support for water related research" (Spence, 1984, 3). "...The Federal Government could take a leading role in research and education relating to various alternatives of water charges" (American Water Works Association, Ontario Section, 1984,9.2). "Fund more research on all aspects of water use and ecology" (Alberta Wilderness Association (1984, 15). These four comments present a message which was repeated many times in submissions to the Inquiry on Federal Water Policy. The Federal Government has a role in water resources research as both a "doer" and a "facilitator", and there is need for additional support for water resources research in Canada.

The Federal Government has explicitly recognized that it does have a role in water resources research. In a policy statement on inland waters, Environment Canada (1978a) noted that

> The federal government...has a general mandate for conducting research, collecting data and maintaining inventories relating to surface and subsurface water, pollutants and contaminants, fisheries and aquatic ecosystems, atmospheric water, and snow and ice.

In that statement, 16 specific policies were identified. Policy number 14 declared that:

> The federal government undertakes water research and technology development programs, provides for additonal research and development by contract, and supports through funding, research on water-related problems carried out by non-federal agencies.

Within such a policy framework, Environment Canada (1978a) stressed several considerations. First, research in the natural sciences, social sciences and wastewater treatment technology was viewed as necessary to develop the new knowledge required to formulate and implement water management and pollution abatement programs. Second, co-operative effort within these various fields was essential to ensure better use of Canadian water resources. Third, governmental and non-governmental agencies were seen to have different, but complementary roles in carrying out water resources research.

In a subsequent review of water resources research in the country, Environment Canada (1981a,1) indicated that water resources research had

seven basic goals. Drawn from a study by the U.S. Federal Council for Science and Technology (1966), these included:

(1) understanding the nature of water, the processes which determine its distribution in nature, its interactions with its environment and the effects of man's activities on the natural processes;

(2) developing methods for conserving and augmenting the quantity of water available;

(3) perfecting techniques for controlling water so as to minimize erosion, flood damage and other adverse effects;

(4) developing methods for managing and controlling pollution so as to protect and improve the quality of the water resource;

(5) developing and improving procedures for evaluating water resource development and management so as to maximize socio-economic benefits;

(6) developing techniques for efficient design, construction and operation of engineering works at minimum costs; and,

(7) developing new methods for efficient collection of the field data necessary for the planning and design of water resource projects.

This discussion reveals that the federal government has recognized and accepted a role for itself in water resources research. This role has received, and continues to receive, strong endorsement from individuals and organizations associated with the water field in Canada. In that context, the federal government has explicitly stated an overall strategy for its involvement in water resources research, and has identified a set of basic goals for such research.

1.2 THE PURPOSE OF THIS STUDY AND ITS RELATIONSHIP TO PREVIOUS STUDIES

This study is the third to examine water resources research in Canada. The first review was started late in 1966 when the Science Council of Canada created a study group to investigate the state of water resources research in Canada. That activity led to a substantive report by Bruce and Maasland (1968) regarding the situation in 1966, as well as to shorter reports by Chevalier (1969) and Sewell, Judy and Ouellet (1969). The Science Council of Canada (1968, 1) concluded that water resources research was "important but....that it has attracted neither adequate attention nor money. Government laboratories do good work but universities lack funds and industrial research is undeveloped".

To strengthen water resources research in Canada, the Science Council (1968, 29-30) offered a series of recommendations. First, more support was needed for subjects which had been neglected but were critical for Canada. The subjects requiring emphasis included particular aspects of water pollution, social and legal aspects of water, ecological impacts from water development, engineering equipment and materials, and some aspects of the water cycle. Second, the Science

Council (1968, 29) argued that

> Water resources are so important to Canada and research has been so neglected that the Council recommends an increase in expenditures on research and development in this field at an annual rate of 20 percent from $8.4 million in 1966 towards a target of $25 million in 1972-73.

Third, the Council believed that the research capacity in industry should be strengthened, and that this could be achieved by contracting a large proportion of research and data collection to private companies. Fourth, university participation in water research needed encouragement which could be realized through the federal government "assisting the establishment in Canadian universities of a few major research institutes specializing in different fields".

The Science Council devoted an entire section of its report to "the co-ordination of Canadian programs in water resources research". To facilitate better coordination, the Council recommended that the existing National Advisory Committee on Water Resources Research be modified to ensure more equitable representation from government, universities and industry. Furthermore, the Council urged that the National Advisory Committee should be responsible for providing continuing advice to the Minister on the use and application of science to water resources management and development, and for advising on the distribution of research funds to assist university and industrial research.

The second review was initiated by the Inland Waters Directorate of Environment Canada "to determine the current level and direction of research in water resources in Canada, and thus make it possible to identify the appropriate direction for future research efforts" (Lefeuvre, 1984, 1). This review was conducted in two phases. A questionnaire and personal interviews were used to document the research effort in 1979. Data were collected using the same research categories as the Bruce and Maasland (1968) report to facilitate comparisons. Subsequently, regional workshops were organized to obtain viewpoints from both water managers and research managers in various regions of the country.

Lefeuvre (1984, 5) reported that a comparison of research effort in 1966 and 1979 showed that total funding had increased to $52 million in 1979 from $20 million (1979 dollars, or 8.4 million in 1966 dollars) in 1966. Lefeuvre (1984,9) noted that the 250 percent increase in water resources research effort between 1966 and 1979 fell far short of the Bruce and Maasland (1968) recommendation that research support increase at a rate of 20 percent per year. Using the Bruce and Maasland recommendation, the level of support should have increased ninefold by 1979 (Lefeuvre, 1984, 11). The 250 percent increase over 13 years was considered "significant" but "more indicative of the very low resource level in 1966 than of a sufficient resource commitment in 1979".

In terms of substantive emphasis, this second review found that funding for water quality management and protection advanced from 30 percent of total funding in 1966 to 40 percent in 1979-1980. In contrast, over the same period, support for research on the water cycle dropped from 47 percent to 24 percent. A new focus emerged as well, with the expenditure for environmental management and protection growing to 16 percent of total funding in 1979 whereas it was not even recorded as a separate category in 1966. No specific recommendations were presented in this second review regarding needed work, level of support, nor management of research effort.

This study is the third review, and is co-sponsored by the Science Council of Canada and the Inquiry on Federal Water Policy, each of which provided one-half of the funds for the study. The Science Council's interest in water resources research extends back at least until 1966 when it initiated the first assessment. In its terms of reference, the Inquiry on Federal Water Policy was directed to address four concerns, one of which was to "assess the needs for and nature of additional scientific and research expertise in water management in Canada".

Given the joint interest of the Science Council and the Inquiry in water resources research in Canada, the following terms of reference were developed for this study. The objectives were:

(1) to update the inventory of water research activities, using the Bruce and Maasland report of 1968 and Environment Canada paper of 1979 (Lefeuvre report, 1984) as bases, identifying changes in effort among research categories and changes in effort and funding among federal, provincial, university and private sectors.

(2) to identify future research needs and priorities, in consideration both of current trends and emerging water issues as substantiated by the Inquiry on Federal Water Policy.

(3) to evaluate federal research programs in terms of their capacity to respond to changing priorities for water resources research, co-ordination and management in Canada.

1.3 WATER RESEARCH AND RELATED SCIENTIFIC ACTIVITY

As in the previous two reviews, it was necessary to decide what was to be included in water resources research and related scientific activity. The Science Council of Canada (1968, 12) had used the following definition: "Research is work undertaken primarily for the advancement of scientific knowledge, with or without specific application in mind. Work in which the element of innovation was lacking, such as in the regular collection of scientific data, was not considered to be research". This same definition was utilized in this study.

It is noteworthy that such a definition does not include items such as data collection, technology transfer, and education and training. Those elements are frequently referred to as "grey" areas of research since they are fundamental elements of a robust research program. This is particularly true for technology transfer since without specific mechanisms for disseminating the research findings, the full utility of the research may never be realized.

In the development of this study, the viewpoint of the Australian Water Resources Council (1982, 31) during a review of the water research in that country, was adopted. In the words of the Council, the ... objectives were not to define the boundaries of this research but, rather, to recommend how it could be more effectively carried out". Thus, considerable efforts were directed toward determining possible approaches to the role of the federal government and how it might best participate in water resources research.

As noted in Section 1.2, the terms of reference directed this review to update the inventory of water research activities in the Bruce and Maasland (1968) and Lefeuvre (1984) reports. As a result, to facilitate comparisons of research activity and effort it was necessary to use the same major research categories as the earlier studies. These are:

1. Nature of Water
2. Water Cycle
3. Water Supply Augmentation and Conservation
4. Water Quantity Management and Control
5. Water Quality Management and Protection
6. Economic, Social and Economic Aspects
7. Resources Data
8. Engineering Works
9. Environmental Management and Protection.

The ninth category was added in the Lefeuvre (1984, 4) report to reflect the emergence of environmental management and environmental impact assessment. Specific categories are listed in Appendix 1.

These categories were used to allow comparisons over time. At the same time, it was fully appreciated that many research projects do "not fit neatly" into such a categorization (Lefeuvre, 1984, 2). In addition, a series of problems mentioned by Dorcey (1984, 7) were recognized from the outset. The categories for classifying research are not always

clearly separable. This issue is compounded in interdisciplinary and policy-oriented studies which consciously involve a mix of these categories and strive to integrate them. The ambiguities in the categories combined with a loose definition of research, raise difficulties in interpreting responses to the survey of research activity and effort. As a small consolation, it also was recognized that any two researchers would be unlikely to agree on definitions for research or appropriate categories for classifying research activity.

1.4 DATA COLLECTION

The study was initiated in mid June 1984, data collection essentially terminated by mid December 1984, and the draft of the report was submitted to the Science Council and the Inquiry on Federal Water Policy in late February 1985.

Several methods were used in this study to assemble data. To update the inventory of research activity and to allow comparisons, a survey was utilized which used the same research categories and questionnaire as Bruce and Maasland (1968). The Bruce/Maasland questionnaire was augmented through the addition of a series of fourteen questions requesting subjective responses to a series of issues. The resulting questionnaire is contained in Appendix 1.

The questionnaires were distributed late in July 1984, and respondents were asked to reply by the middle of September 1984. A subsequent mailing of the questionnaire was carried out in early October to those in universities and private industry thought to be active in water research but who had not responded to the initial mailing. The potential respondents were identified through consultation with professionals in the federal and provincial governments, the universities, and the private sector. Valuable guidance was provided by Dr. Allan Prince, former Director General of the Inland Waters Directorate, who served as a consultant in this phase of the study. In general, a "top-down" approach to questionnaire dispersal was adopted. In requesting information from universities the questionnaire was sent to the Deans of faculties in Canada with the request that they then disperse copies to professors within their faculty. This approach was adopted as a means of assuring a greater likelihood of opportunity for individuals to respond.

Table 1.1 shows the number of questionnaires distributed and the resulting number of responses received. The response rate was encouraging, given that the questionnaire was distributed in mid-summer, a necessity if the data were to be collected in the time-frame demanded by the work schedule of the Inquiry on Federal Water Policy. A further limitation was the length and complexity of the questionnaire, which undoubtedly discouraged some who received it. However, it was felt that since the respondents were all directly associated with water research, the interest and motivation to respond should be present. From some comments received, that assumption was not universally valid.

While the questionnaire was being completed by respondents, data were collected on the mandates and research activities of pertinent federal government departments. A variety of published reports were

Table 1.1 Questionnaire Responses

Research Sector	Number of Questionnaires Distributed	Number of Questionnaire Responses
Federal	13	51[#]
Provincial	25	20
University	102	61[+]
Private Industry	182	64[*]
Total	322	186

[+] many responses reflected the views and activities of a group of individuals.

[*] although a number of responses were received, many consisted simply of statements that no research was being done. On the other hand, a number of companies known to have considerable on-going research, did not complete the questionnaire.

[#] response rate reflects "top down" distribution method discussed in Section 1.4.

used. In addition, Dr. Prince worked in Ottawa to assemble information on behalf of this study. He examined the federal estimates and other records, and abstracted information about level of financial support and person-years devoted to water research.

A workshop was held in Kitchener, Ontario, on November 7 and 8, 1984, to generate further ideas regarding water research. The workshop had several objectives: (1) identification of a national strategy for, and federal role in water resources research, (2) discussion of needed research, (3) consideration of the level of support and rationalization for water resources research, and (4) exploration of alternative approaches for the management of research efforts.

Participants were invited so as to ensure a cross-section of federal, provincial, private sector and university people, as well as to ensure a mix of professional/disciplinary and regional perspectives. Nineteen people participated, coming from six provinces. Participants prepared papers for distribution prior to the workshop itself. The names and professional associations of the workshop participants are included as Appendix II.

During the workshop, participants were given preliminary results of the questionnaire survey. In addition, members of the Inquiry on Federal Water Policy outlined the concerns of the Inquiry and reported on the public hearings which had been held to that point-in-time. The majority of the workshop was devoted to small group discussions in which different combinations of participants met to consider alternative approaches to the objectives identified above. During the final part of the second day, all of the participants met together to explore the various issues identified during the small group discussions.

Other data sources also were used within the development of this study. The staff of the Inquiry forwarded copies of submissions from the public hearings which were judged to have suggestions pertinent to water research. Informal interviews were held in person, and by telephone. These interviews ranged from discussions with Dr. Lefeuvre concerning the second study on water research in Canada, to individuals in federal research institutes and provincial orgnizations, the private sector, and universities. Letters were sent to request information regarding the state of water research in selected countries. Finally, other studies of water research were sought and examined. The overall intent was to ensure that a range of cross-checking data sources was employed. While gaps and weaknesses still exist, it is felt that the above procedure was realistic and defensible in the time available for the study.

1.5 REPORT ORGANIZATION

The following chapters are organized to address the three questions this study was asked to consider. With regard to research effort, Chapter 2 describes the current arrangements for water resources research in Canada, identifies some of the mechanisms developed to facilitate coordination and communication of research activities, identifies a number of constraints which influence arrangements for research, presents information about levels of funding and nature of

effort in research, and finally, provides two case studies regarding the funding patterns for two organizations. While the second chapter presents basic information about research activity in Canada, the third chapter presents the reactions and views of the research community relative to some of the issues and concerns which constrain and inhibit research efforts. Thus, Chapters 2 and 3 should be viewed as complementary, both addressing different aspects of research effort. These two chapters provide the context for subsequent chapters dealing with research issues and research strategies.

Chapter 4 provides an overview of substantive water research issues which are judged to be of national significance and therefore pertinent to the federal role in water research. Chapter 5 outlines an overall strategy for water resources research, while Chapter 6 presents conclusions.

Chapter 2

NATURE OF THE RESEARCH EFFORT

2.1 CURRENT ARRANGEMENTS FOR WATER RESOURCES RESEARCH IN CANADA

Water resources research is conducted in Canada within the federal government, the provincial governments, universities, and the private sector. Within the federal government, Rodgers (1984, 1) has noted that "water research takes place in a dozen or so agencies" and in addition that "the variety of agencies funding water research do not, in general, have common objectives notwithstanding important alliances on several issues. It would be misleading to consider water research of all agencies as a homogeneous effort".

Before reviewing the current arrangements for water resources research, it is appropriate to identify several significant developments since the Bruce and Maasland report in 1968. Two major federal inland waters research establishments were created. The Canada Centre for Inland Waters, the headquarters for the National Water Research Institute, was established at Burlington, and the Freshwater Institute was established at Winnipeg. Furthermore, the National Hydrology Research Institute, now based in Ottawa, currently has new headquarters under construction in Saskatoon. In addition, the International Hydrological Decade (1970-1979) and the Canada/USA Great Lakes Water Quality Agreement (1972;1978) provided powerful stimuli for research activity, even if a considerable portion of it was on a one-time occurrence. Finally, creation of Departments of the Environment at federal and provincial levels consolidated much of the environmental activity into single organizations, and provided a base for substantial investments in water quality research during the 1970's and 1980's. Against this background, the present arrangements for research in the federal and provincial governments, universities and the private sector can be reviewed.

2.1.1 The Federal Government

2.1.1.1 Environment Canada

The Inland Waters Directorate (IWD) of Environment Canada is the lead federal agency for water management. In the 1984/85 estimates, water resources research by IWD included $22 million and 212 person-years. The $22 million represents 2-1/2 percent of the total operational budget ($886,879,000) for Environment Canada in 1984/85.

IWD is responsible for gathering and disseminating water quantity and quality data. The Water Resources Branch operates a comprehensive network of streamflow gauging stations and water level stations on lakes. The Water Quality Branch regularly monitors the aquatic environment. For example, at the Canada Centre for Inland Waters, the laboratories conduct an average of 1,000 tests each day for different aspects of water quality. The Water Planning and Management Branch is responsible for flood damage reduction and forecasting water demand. It has been conducting research on the economic impact of designating floodplains as well as on modelling industrial, agricultural and

residential water demand.

An important focus for water resources research in IWD is the Canada Centre for Inland Waters. It has been characterized as "a place, not an agency", which is home to several organizations concerned with freshwater resources as well as serving as a base for hydrographers, oceanographers and land use specialists. In 1983/84, it employed about 559 scientists and support staff, and had a budget of $ 19.2 million in salary, $11.2 million in operating and $2.8 million in capital expenditures.

The Canada Centre for Inland Waters(CCIW) was established in 1966. The purpose was to consolidate in one place the water research activities occurring in the federal Departments of Energy, Mines and Resources; Fisheries and Forestry; and National Health and Welfare. The water components of these three departments became parts of the Department of the Environment formed in 1970 (Environment Canada, 1975, 220). Thus, CCIW can be viewed as a pioneering effort to integrate, coordinate and rationalize water resources research effort at the federal level.

The CCIW was established at Burlington, at the western end of Lake Ontario. The intent was to create a "national centre of expertise in water resources research, including anti-pollution studies" (Environment Canada, 1975, 220). The research and data collection efforts at CCIW are used as input for both federal and provincial programs of water management and development. Furthermore, technical advice is provided during the formulation and implementation of federal water policies and programs.

The National Water Research Institute (NWRI), a part of IWD, has its headquarters at CCIW in Burlington but also has regional centres in Winnipeg and Vancouver. It employs approximately 300 people, most of whom are in Burlington. In contrast, the usual staff complement at the NWRI Branch in Winnipeg is 4 scientists and 5 technicians (Environment Canada, 1982, 149), and this small group, working in cooperation with research scientists at the Freshwater Institute in Winnipeg, is responsible for research pertinent to all three Prairie provinces as well as the Northwest Territories. The Branch based in Winnipeg is viewed by NWRI as fulfilling "the need for local expertise in problem areas specifically regional in nature" (Environment Canada, 1982, 149).

The NWRI conducts water research with reference to chemical, physical, biological and environmental problems of lakes, rivers and reservoirs as well as urban and coastal regions. The Institute is generally perceived to be interested in problems of water quality, and this is reflected in the 5 research divisions within NWRI: (1) aquatic ecology, (2) aquatic physics and systems, (3) hydraulics, (4) analytical methods, and (5) environmental contaminants.

As indicated, the National Water Research Institute is primarily responsible for water quality research although it should be recognized that it has a major program in environmental hydraulics and another in

geophysical fluid dynamics. In contrast, the National Hydrology Research Institute is mainly responsible for research on water quantity although it also conducts work focused on groundwater quality. Specifically, the NWRI specializes in research related to (1) underground waters, (2) snow and ice, and (3) surface water (Environment Canada, 1983, 20).

The Inland Waters Directorate is not the only agency within Environment Canada conducting water-related research.

Also based at CCIW in Burlington is the Wastewater Technology Centre which is responsible for conceiving, developing and providing new wastewater treatment technologies and sludge disposal techniques both for municipalities and industries. Its research is separated into three groups: (1) biological processes, (2) physical/chemical processes, and (3) residue management. The actual research and development is conducted within laboratories and pilot plants at CCIW and in mobile pilot plants which can be transported to industrial sites across the country.

Early in 1984,the Atmospheric Environment Service received Treasury Board approval for phase 1 of the "Canadian Climate Program". The first phase has two priorities: the production of monthly and seasonal climate predictions, and research on CO_2-related climate change and its socio-economic impacts. The socio-economic research will be carried out through contracts, primarily with universities. The funds available for the socio-economic research are $135,000 in 1984-1985, $290,000 in 1984-1986, and $310,000 in 1986-1987 for a total of $735,000. The first round of contracts will focus upon two themes both of which are directly relevant to water management: (1) water resources of the Great Lakes - St. Lawrence system; and (2) food and agriculture in various regions across Canada. Contract money to be allocated in 1985 and 1986 will include research relevant to water resources elsewhere in Canada, forestry, the North, and energy development. In the words of the Director General of the Canadian Climate Program (1984), "Through CCP-sponsored research, we hope to draw on the full range of expertise in both the social and physical sciences needed for this interdisciplinary research, and thereby help to build crucial interdisciplinary capability for the conduct of climate impact studies".

Other Environment Canada organizations also conduct related research. The Canadian Wildlife Service monitors and identifies contaminant levels in wildlife, and thereby gauges the presence and buildup of toxic substances in the aquatic ecosystem. The Lands Directorate maps land use, monitors and assesses land-use changes, and studies terrestrial ecosystem processes. In that manner, its research activity contributes directly to water research programs dealing with acid rain, soil erosion, environmental impact, and land use conflicts.

2.1.1.2 Fisheries and Oceans

In the 1984/85 estimates, the federal Department of Fisheries and Oceans allocated $79,170,000 and 1,127 person-years to fisheries research, or about 11 percent of its total budget on fisheries

research. A significant proportion of that research effort is water-related since the quality of aquatic ecosystems is critical for survival and enhancement of freshwater fish as well as anadromous species such as salmon.

A major concentration of research effort by Fisheries and Oceans is at the Freshwater Institute at Winnipeg. At the Institute, research is conducted on fish habitat and limnology, emphasizing processes and mechanisms of biological production and decomposition in lake systems (Ayles, 1984, 1). Research has covered such aspects as hydroelectric reservoirs, acidification, radionuclide and heavy metal pollution, and toxic chemicals. At the Canada Centre for Inland Waters in Burlington, Fisheries and Oceans operates the Great Lakes Biolimnology Laboratory. Three programs there address environmental toxicology, surveillance, and ecosystem studies, and collectively explore the effects of human activity on the well-being of the Great Lakes fishery and the overall freshwater ecosystem, including the impact of acid rain and other contaminants.

2.1.1.3 Agriculture

In the 1984/85 estimates, the federal Department of Agriculture designated a research budget of $22,637,000 for natural resources (land, water, energy, environmental quality). Of that total, $2,517,000 and 47 person-years were allocated to research related to water. In its submission to the Inquiry, the Department of Agriculture identified four activity areas pertinent to water. First were surveys and monitoring, especially agri-food water use and forecasting. Second, was basic and applied research conducted within the Research Branch. The Research Branch uses a consultative system involving two committees. The Canadian Agricultural Research Council and the Canadian Agricultural Services Coordinating Committee are used to establish research priorities with provincial governments, universities and the private sector. Third, a development program is used to assemble and assess packages of programs which facilitate technology and product transfer. Fourth, activity is focussed upon the regulation and registration of pesticides.

2.1.1.4 National Health and Welfare

The Environmental Health Directorate of the Health Protection Branch, National Health and Welfare, has been in existence for 14 years. The purpose of the Directorate is to protect Canadians from health hazards associated with natural and man-made environments. The present staff of the Directorate is 270 and has an annual budget of approximately 13 million dollars.

In its submission to the Inquiry, National Health and Welfare indicated that it has two distinct roles with respect to water. A national-scale role involves research on, and development of, guidelines for drinking water and recreational water quality. In these respects, the Department undertakes national surveys of drinking water quality for priority contaminants and facilitates cooperative projects among the provinces, such as training of waterworks operators. A "provincial" type of role is undertaken through the provision of environmental health

services in areas under federal jurisdiction such as national parks, reservations, defense bases, and on common transportation carriers, as well as for all communities north of the 60th parallel.

From the departmental estimates, it was difficult to identify the allocation of funds or person-years to water-related research. It was indicated, however, that the research effort allocated to water problems is extremely modest.

2.1.1.5 National Research Council - Associate Committee on Hydrology

The Associate Committee on Hydrology is one of a number of NRC Associate Committees which was established primarily to address problems of national significance which "can be solved by the application of scientific expertise or additional coordinated and focussed research" (Environment Canada, 1981a, 2). Based in the National Research Council, the Associate Committee encompasses more than federal interests. Its 29 members are drawn from researchers and managers from federal and provincial governments, universities and technical societies (Associate Committee on Hydrology, 1984, 1).

The Associate Committee on Hydrology has four functions. First, it facilitates contact among research and operational agencies and individuals in Canada, working in hydrology. Second, it disseminates knowledge and information through organizing symposia and workshops, organizing national lecture tours, as well as publishing newsletters and other reports. Third, it formulates research priorities for hydrology. Beginning in 1976, and every three years after, the Associate Committee has defined aspects of hydrology deserving greater research and experimental development. Fourth, it promotes international hydrologic development by serving as the Canadian National Committee for the UNESCO International Association of Hydrological Sciences.

2.1.1.6 Other Federal Agencies

A variety of other federal agencies conducts water-related research or provides funding for such research. They are mentioned briefly here to complete the picture of the large number of federal agencies involved in water research. The Department of Energy, Mines and Resources conducts or facilitates research related to groundwater. Such work ranges from surveys and monitoring to the exploration of technologies to utilize the energy available in thermal groundwater supplies. The Department of Transport conducts research as it relates to freshwater transportation and navigation. Significant effort has been devoted to developing and testing technologies to extend the length of the shipping season in the Great Lakes - St. Lawrence system. The Department of Indian and Northern Affairs, responsible for that part of Canada north of 60 latitude, has been involved in a variety of water research activities, ranging from work to support comprehensive basin studies for the Yukon and MacKenzie Rivers, to research related to possible water pollution associated with resource development projects in the North.

2.1.2 Federal Granting Agencies

In Section 2.1.1, the focus was upon the mandates and responsibilities of federal line agencies and other organizations related to water research. Such organizations both conduct research in-house as well as contract out such work to the private sector and universities through the Department of Supply and Services or through various research support programs. However, through the traditional granting agencies, the federal government also makes substantial funds available to the university research community. In this section, the characteristics of these funding agencies are described with regard to a comment that "'pure researchers' in water should compete with 'pure researchers' in any other field for pure research funding from the general funding sources" (Cardy, 1984, 2). The three major funding agencies and their level of support are shown below.

Funding Agencies and Levels of Support

	1983 - 1984	1984 - 1985
Natural Sciences and Engineering Research Council of Canada	$ 282,100,000	$ 291,300,000
Medical Research Council	$ 137,312,984	$ 156,900,000
Social Sciences and Humanities Research Council of Canada	$ 54,400,000	$ 62,800,000

2.1.2.1 Natural Sciences and Engineering Research Council of Canada

The functions of NSERC are to promote and assist research in the natural sciences and engineering other than the health sciences. Fields which are supported include agriculture, biology, biotechnology, chemistry, engineering, environmental toxicology, forestry, geography (physical), geology, oceans, physics, and interdisciplinary. Support is given to academic staff members of Canadian universities. Work is funded under six major activities: research grants (operating and strategic), research infrastructure grants, university-industry programs, developmental grants, general research support, and research manpower awards.

During 1983-1984, NSERC supported over 17,000 individuals through its programs of grants and scholarships and launched its University-Industry program to encourage interaction between university researchers and Canadian industry. Research grants totalling $160.1 million were awarded, including 5,933 discipline research grants. Scholarships and fellowships totalled $40.2 million and were distributed to 1,494 undergraduate and 2,422 graduate students. A comparison of NSERC's 1983-1984 budget of $282.1 million with that of 1979-1980 ($120.7 million) reveals a 135 percent increase in current dollars, or when inflation is considered, a real increase of 57 percent (NSERC, 1984).

2.1.2.2 Medical Research Council

The MRC supports research in the field of health sciences. Since some diseases are communicated or nourished by water, some funds from the MRC could support water-related research. During 1983-1984, the MRC allocated $137.3 million to support health sciences research, of which $83 million was distributed under "grants in aid for general research".

2.1.2.3 Social Sciences and Humanities Research Council

SSHRC was established in June of 1977 and began operating in April 1978. It took over programs in the humanities and social sciences previously handled by the Canada Council. Its mandate is to promote and assist research and scholarship in the social sciences and humanities. SSHRC (1984, 22) noted that its budget increase from 1978-1979 ($30.4 million) to 1983-1984 ($54.4 million) represented a growth of 79 percent. However, if inflation is taken into account and the comparison is made in constant 1978 dollars, the increase was from $30.4 million in 1978-1979 to $31.9 in 1983-1984, a real increase of only 5 percent.

2.1.2.4 Interdisciplinary Research

NSERC, MRC and SSHRC consider applications for major interdisciplinary research projects which overlap the mandates of the granting agencies (NSERC, 1984a, 3). In such situations, investigators are directed, prior to submitting a proposal, to contact the agency judged to have the major interest in the research. The Councils then endeavour through discussion to ensure that arrangements are made for appropriate assessment.

Interdisciplinary proposals also may be considered by an agency if a proposal overlaps several disciplines within that agency's mandate. To illustrate, NSERC (1984a, 15) has an Interdisciplinary Grant Selection Committee to cover situations when formal consultation between two or more other grant selection committees is not adequate to ensure a thorough evaluation. The Interdisciplinary Committee involves a small core membership with advisors drawn from other grant selection committees, or from outside sources, depending upon the circumstances. Thus, in theory, a mechanism does exist for the review of interdisciplinary research proposals, although most of the appraisers are selected from a pool of reviewers who were originally selected for their expertise in a specific discipline.

Nevertheless, many researchers responding to the survey conducted as part of this review expressed doubt as to the commitment of the major funding Councils to interdisciplinary research. Slivitsky (1984, 10) has concisely summarized some of these concerns:

> ...a number of specific research projects which cross the boundaries of chemistry, earth science and biology end up with the committee for interdisciplinary research which has yet to find proper ways to completely fulfill its role. The same could be said for problems which fall between the "engineering" committees and the "pure science" committees: too fundamental for the first -- too applied for the second.

The issue of integration becomes even more demanding and difficult when it involves bringing together the social and natural sciences as compared to integrating research among the natural sciences alone. This issue is critical when it is appreciated that policy-oriented research usually must address problems which cut across the natural and social sciences.

2.1.2.5 Environment Canada, Inland Waters Directorate, Water Resources Research Support Program

In addition to applying to NSERC, MRC and SSHRC, university-based investigators may also apply to research programs administrered by line agencies. The Water Resources Research Support Program (WRRSP) of the Inland Waters Directorate is the main research program for water resources reserch.

The WRRSP is one element of Environment Canada's overall Science Subvention Program which was designed to help Environment Canada realize its objectives through facilitating development of ideas generated by non-government scientists. The program supports research with "a significant component of concept development and exploration of novel approaches". Disciplinary or interdisciplinary research involving the physical, biological, engineering and social sciences may receive support. A primary concern is "to establish an effective dialogue between non-government scientific institutions and the Department in areas of mutual interest and concern" (Environment Canada, 1984).

The level of funding for the WRRSP program has been reduced substantially over the past decade. For 1973-1974, the WRRSP provided grants totalling $1,146,660. Of that total, $276,660 was given to support 44 individual projects at 24 universities (Environment Canada, 1975, 224). The balance of $870,000 provided support to 6 Canadian universities for continuing development of interdisciplinary water resources research centres (Westwater Research Centre, University of British Columbia, $180,000; Division of Hydrology, University of Saskatchewan, $140,000; Agassiz Centre for Water Studies, University of Manitoba, $155,000; Wastewater Treatment Centre, McMaster University, $125,000; Institute of Environmental Sciences and Engineering, University of Toronto, $140,000; Le Centre de Recherches sur l'Eau, Laval, $130,000).

By 1976-1977, the WRRSP provided $1,000,000 which was shared among 21 universities to study problems in nine priority areas identified by Environment Canada (1976). During 1978-1979, the WRRSP again allocated $1,000,000, to 24 universities for research in seven priority areas specified by Environment Canada (1978, 1).

However, in August 1978 the Government of Canada announced that as part of general restraint, the WRRSP would be reduced from $1,000,000 to $250,000, effective in April 1979. Thus, by 1982-1983, the $250,000 was distributed to only 13 universities (Environment Canada, 1983, 24). By 1984-1985, this same level of funding was directed by Environment Canada (1984) towards "a limited number of specific high priority areas" and it was expected that "not more than 10 to 12 proposals will be funded".

In response to this cutback, researchers attempted to persuade NSERC to identify water as a candidate field for support under its Strategic Grants program. However, Slivitsky (1984, 11) has reported that "NSERC has replied to such requests that not enough related proposals have appeared in the open area over the last few years to justify such an initiative". This situation led the Inland Waters Directorate in January 1984 to contact investigators to encourage them to submit water-oriented proposals to NSERC. The hope was that if a substantial increase in water research proposals were received, then NSERC would decide to include water in the Strategic Grants program. However, this pattern of funding in the WRRSP provides confirmation for Rodger's (1984, 3) observation that "support for water research in universities has decreased considerably in the past 7 to 10 years". This reduction has generated concern by many individuals and groups making submissions to the Inquiry. The Canadian Water Resources Association (1984, 16) expressed concern about "what appears to be a reduction in real federal dollars made available for water resources research" and along with other groups, urged that this trend be reversed.

Other concerns also have been expressed. In the words of the Saskatchewan Research Council (1984, 6-7), "the subvention program is not effective because the same group of people get the money and which is too small an amount for effective research". In addition, the Saskatchewan Research Council (1984, 6) queried why the subvention program was available only to university scientists. It argued that the program should be open to investigators employed in a range of institutions which would include governmental and private organizations.

2.1.3 Provincial Governments

While the federal government has many agencies active in conducting or supporting water research, the provincial governments also provide support for water-related work. Given their responsibility for management of water within provincial boundaries, provinces have devoted funds for monitoring of water flow and testing of water quality. The provinces also have given funds for background studies for comprehensive river basin plans, many of which have been joint, co-operative efforts with the federal government.

Many of the provinces also fund research councils such as the Alberta Research Council or Saskatchewan Research Council which devote some of their research effort to water problems specific to that province.

2.1.4 Universities

Environment Canada (1975, 224) has stated that "since universities are the major source of research manpower, strong programs in water research at these centres are prerequisites for performance in the other research sectors". However, research activity at the university level is not a homogeneous effort, but instead can be pursued in many ways".

Multidisciplinary or interdisciplinary research centres which focus upon water research can be established. Examples are the now defunct Agassiz Centre at the University of Manitoba, and the Westwater Centre at the University of British Columbia, entering its 15th year of operation in 1985. Alternatively, multidisciplinary institutes or programs may exist which address water as one of several resource management concerns. Examples here are the Masters of Natural Resource Management program at Simon Fraser University and the Institute of Environmental Studies at the University of Toronto. A third alternative is a group research program focussed upon a selected aspect of water, such as the Division of Hydrology at the University of Saskatchewan, the Water Conservation Program at the University of Waterloo or the Watershed Ecosystem program at Trent University.

Other approaches include small groups of scientists which form to undertake a specific study, and then dissolve themselves until another situation arises in which that combination of expertise is needed, or individuals or small teams can undertake projects either through research grants or contracts. This category normally accounts for the greatest activity both regarding manpower and allocated funds.

University water researchers obtain nearly all of their research funds from outside their universities, usually from government line agencies, granting agencies, or the private sector. In a national strategy for research, therefore, it is important that consideration be given to encouraging the different types of research activity ranging from the large interdisciplinary centre or institute to the individual scholar.

A noteworthy exception with respect to funding sources is the Centre for Water Resources Studies at the Technical University of Nova Scotia which receives a grant of about $20,000 from the university to assist the administration of the Centre. The Centre was established in 1981 to encourage coordinated research programs in water resources.

2.1.5 The Private Sector

Research activity in the private sector is the most difficult category to inventory because of the diffuse, and confidential nature, of much of the work. Industrial and manufacturing firms often conduct inhouse research to make their water use more efficient or to reduce wastes to be discharged into receiving waters. However, because this

work is usually undertaken to enhance the profitability of the firm, the results are not often published in the normal research journals. Furthermore, since the time for such work usually involves individuals doing a number of tasks in parallel, it is difficult to inventory the effort.

Associations representing private sector interests also may fund work. For example, during the autumn of 1984 the Canadian Electrical Association invited proposals to conduct research to determine the extent to which environmental predictions made during environmental assessments of selected hydroelectric projects in Canada were confirmed during post-development experience. The CEA was providing a budget of $100,000 and stipulated that the work was to be completed within one year. Such research involves activity that is pertinent to water research, and yet determining what proportion should be categorized as water research is difficult. The twin difficulties of identifying resarch activity in the private sector and estimating which proportion is "water-related" ensure that estimates regarding water research in the private sector can only be of a "ball park" variety.

Consulting firms conduct research for government agencies and the private sector. The work can range from multi-million construction projects in Canada or overseas, to two or three-day projects for municipalities or small firms. Due to the large number of consulting firms, it is difficult to inventory their effort.

A source of funding for water resources research is the private foundation. Since 1975, the Devonian Group of Charitable Foundations, based in Calgary, has had available capital, plus income, of $71 million. In conjunction with the Canada West Foundation, the Devonian Group supported a study of the water resources of interior western and northwestern Canada from 1979 to 1982. Based in Toronto, the Donner Canadian Foundation (1984) has identified "oceans and inland waters" as one of five fields for which it will provide support. Donner indicates that "prime consideration is given to applications which do not fall under the terms of reference of other agencies active in the field, and to experimental ventures for which seed money is not always available". Two water-related projects were funded in 1983. The North American Wildlife Foundation received $225,000 for research on waterfowl and wetland ecology at the Delta Waterfowl Research Station near Portage la Prairie in Manitoba. The Rawson Academy of Aquatic Science was given $124,400 to conduct a major review of water resources in Canada.

2.2 COORDINATION AND COMMUNICATION OF RESEARCH ACTIVITY

Given the wide array of organizations and individuals involved in water research, it would seem reasonable to assume that overall effectiveness would be improved if the effort were coordinated and if the participants maintained contact with one another. A number of mechanisms for coordination and communication exist. Those which are in use are briefly reviewed below.

2.2.1 Coordination Mechanisms

2.2.1.1 Interdepartmental Committee on Water

The Interdepartmental Committee on Water (ICW) was created to facilitate interdepartmental considerations and approval of "all federal water programs" (Environment Canada, 1983, 3). It usually meets about three times a year, and in the year ending on March 31, 1983 it had 26 members representing a total of 20 departments and agencies with an interest in water matters. Subcommittees and Working groups are established as required. During 1982-83, 4 subcommittees existed: (1) Canada-US, Great Lakes Quality Agreement, (2) water quality, (3) floods, and (4) to prepare responses to IJC reports. Two working groups were concerned with containerized water export and preparation of a federal water strategy paper. No subcommittee or working group explicitly addressed research on a comprehensive basis.

Even if research were explicitly and systematically addressed by the federal Interdepartmental Committee on Water (ICW), an evaluation completed by Environment Canada (1981, 16-17) raises serious questions about the adequacy of such a mechanism. In the review it was concluded that while the Inland Waters Directorate approached the consultative function of the committee in a serious manner and used it as a vehicle for interdepartmental review of its own programs, "other agencies are more likely to make decisions and let ICW know as an information item later". Furthermore, the ICW was viewed as a headquarters institution which did not appear to strengthen regional coordination of federal activities.

2.2.1.2 National Research Council - Associate Committee on Hydrology

The Associate Committee on Hydrology exists to foster contact between research and operational agencies and individual scientists, to disseminate knowledge and information, and to formulate research priorities. Within its narrow concern of hydrology, it undoubtedly does a reasonable job since it incorporates people from federal and provincial agencies as well as universities and industry. However, it does not, and can not, serve as a coordinating group for the broad mix of water research issues which range from quantity to quality and from health to agricultural concerns.

2.2.1.3 Canada Centre for Inland Waters

CCIW was established to consolidate in one place, the water research activities of three federal departments. That was a forward move in integrating federal water research efforts, but by itself has not been sufficient to coordinate water research at the federal level since many line agencies are not represented at Burlington, nor at the regional offices of NWRI.

2.2.2 Data Management Systems

Data and information reference systems can serve as a vehicle to keep investigators informed of the results of research activity across the country. The federal government operates a number of such data management systems (Environment Canada, 1983, 25-26).

WATDOC provides direct, nationwide access through computer terminals to an inventory which lists water-related articles and reports. WATDOC is publicly available through an on-line storage and retrieval system. NAQUADAT, the national water quality monitoring program's data bank, stores and retrieves chemical, physical, bacteriological, biological and hydrometric data pertinent to water quality. STAR is a system for limnological data generated from monitoring cruises on the Great Lakes. WATENIS is a water effluent national information system. It provides an inventory of industrial and municipal water pollution sources as well as information regarding water effluent regulations and guidelines. MUNDAT, a data base for municipal waterworks and wastewater systems, was developed in cooperation with the provincial governments and the Federation of Associations on the Canadian Environment (FACE). HYDAT has been developed to store and retrieve data on streamflow, water levels and sediment transport collected through federal-provincial Water Quantity Agreements.

From these examples, it can be seen that the federal government has taken considerable initiative in developing data management systems which should be useful to researchers in federal and provincial governments, universities and the private sector. As with all such data management systems, a key is to ensure that potential users are aware of the systems and their characteristics, and that the systems are accessible to users. The worth of such systems cannot be assured by their existence. Consequently, an assessment of these data management systems would be appropriate.

2.2.3 Journals

Refereed articles in journals represent a source which researchers traditionally rely upon to keep abreast of work in their field. Several water-oriented journals exist in Canada. The Canadian Water Resources Journal (Revue Canadienne des Ressources en Eau) is published quarterly by the Canadian Water Resources Association, a national non-governmental organization now in its 38th year. The first issue of the Journal appeared in October 1976, published with financial assistance from Environment Canada. The journal gives preference to papers focussing on information and policy aspects. Papers are published in both English and French.

The Water Pollution Research Journal of Canada (WPRJC) is sponsored by the Canadian National Committee of the International Association of Water Pollution Research and Control. Papers focus on all aspects of water pollution research. Before 1984, the WPRJC was published by the University of Toronto. One issue was published each year with a focus on the engineering aspects of pollution. A small Editorial Board was dominated by university engineering departments based in southern Ontario. In 1984, the Chief Editor became an individual at the National

Water Research Institute, and the Editorial Board was expanded to include scientists from government agencies and universities across the country. By 1986 it is intended that the journal will be published quarterly.

The Canadian Journal of Civil Engineering is published bimonthly by the Canadian Society for Civil Engineering. Research papers relevant to water resources are included within categories of hydrotechnical engineering and environmental and sanitary engineering. Supporting contributions to the costs of publication are made by the National Research Council of Canada.

Eau du Québec is a journal published by the Association Quebecoise des Techniques de l'Eau which was founded in 1962. It is published quarterly. All papers are in French, with the focus upon water and wastewater treatment in Quebec. The journal is oriented to researchers and practitioners in the public, university and private sectors.

Thus, in Canada there exist a number of journals through which research findings can be disseminated. However, Canadian journals do not always ensure that good communication occurs between the researchers and the managers, or users. As Cardy (1984) observed, research findings may not be used if they are published in "a very technical or high-powered research journal which practitioners don't read. (This is common because researchers are rated by their peers not by the application of their research, so they aim to publish in the most prestigious journals, not the most widely read)".

Another consideration is that regardless of the number of Canadian journals, researchers also will publish their research in international journals. This may be done for one or more of several reasons. As Rodgers (1984, 7) commented:

1. Staff look to international recognition for promotion criteria.
2. Canadian journals, where they exist, lack the stature of international publications.

Slivitzky (1984, 8-9) expressed a similar concern when noting that "the growing tendency to publish outside of Canada and in very specialized journals does not tend to bring the results to the attention of the users. Most of these journals, especially the ones recognized by the peers, are unknown or unread by the professionals in operating agencies".

2.2.4 Conferences and Workshops

A variety of conferences and workshops are held every year, ranging from annual and regional conferences of the Canadian Water Resources Association to "one-shot" events such as the Government of Ontario's "Futures in Water Conference" in June 1984 or the Rawson Academy's symposium on "Canada's Waters: The State of the Resource" to be held during late May 1985. In addition, organizations such as the NRC - Associate Committee on Hydrology and the Canadian Society of Civil Engineers organize technical meetings to facilitate exchange of research results.

Dissatisfaction appears to be growing with regard to large conferences in which presentations are restricted to 10 or 15 minutes and in which "there is barely time for a question following most presentations" (Cardy, 1984). In this context, enthusiasm is expressed for more workshops, smaller group gatherings, less reading of papers, and more discussion, debate and exchange of ideas. In this regard, the federal government has taken some positive initiatives. For example, in May 1982 the Inland Waters Directorate convened a 3-day workshop on "Social Impact Assessment and the Flood Damage Reduction Program" in which federal government and other experts met for an intensive discussion ranging over program effectiveness and research requirements. A similar format was used in November 1982 in a technical workshop focussing on Streamflow Forecasting.

2.3 CONSTRAINTS AND REALITY

2.3.1 Fragmentation of Research Effort

Because water has an influence on so many human activities, it is not surprising that a number of federal line agencies allocate some of their research effort to water. Environment Canada, as the lead agency, addresses both quantity and quality issues. Fisheries and Oceans is concerned with water-related problems which have implications for the fishery. National Health and Welfare addresses health and safety aspects, especially drinking water and waste disposal. Agriculture examines the role of water in the production of food. The ministry of Transport focusses upon transportation on inland waters, particularly significant in the Great Lakes - St. Lawrence River system. The outcome is a dispersion of research effort amongst a variety of federal line agencies which have associated institutes and laboratories scattered across the nation.

Fragmentation of research effort is exacerbated further when it is appreciated that the provinces have a major responsibility for water management within their jurisdictions, and therefore also invest money and human resources in water-related research through line departments responsible for natural resources and the environment. In addition, many of the provinces have research institutes or centers which devote some of their attention to water problems. When the provincial and federal research effort is viewed in conjunction with water-related research activity in universities and the private sector (industry, consultants, foundations), it becomes apparent that a major management issue is how to coordinate and integrate research activity which is dispersed across many organizations located across the country.

At the moment, although various attempts at coordination have been made, there appears to be scope to make more effective use of the water resources research funding and talent in the country (Section 2.2). As a senior federal official responsible for managing water research commented, "Somebody has to be accountable for specific objectives and be given reasonable control over the resources to achieve those objectives. As it stands at the moment, the control is widely separated".

2.3.2 Regulatory Role

In addition to being fragmented among a variety of line agencies, the federal water research programs often must function to support the regulatory or operational responsibilities of line agencies. This situation is particularly significant for the lead water agency, Environment Canada. About 25 percent of the research and scientific service functions of NWRI have, through commitment in Treasury Board submissions, been directed to Great Lakes Water Quality problems.

Given the important regulatory mandate of such federal agencies as Environment Canada, the research managers encounter significant constraints when conceiving and designing research. In other words, the range of choice of research projects is restricted substantially by the regulatory mandate of the organization. Pressure exists for water research in such agencies to be short-term and mission-oriented rather than long-term and basic in nature. Such pressure in itself is not necessarily inappropriate given the needs of the line agency, but it does contribute to a situation in which relatively low priority is given to anticipatory research focussed upon the problems of the future, rather than those of the present.

2.3.3 Centralization

As in many fields of research, the cost of equipment for regular monitoring and/or experimental testing is rising steadily. Within the federal government in the last five years, this consideration has been an important influence in a trend toward centralization of research activity. Not only has centralization been pursued to realize economies of scale for expensive and sophisticated equipment, it also has been viewed as desirable by creating concentrations of researchers who can interact with, and stimulate, one another.

These real advantages of centralization - scale economies and synergistic effects from concentrated groups of investigators - must be balanced against some negative considerations. Acquisition of expensive and sophisticated equipment can lead to a bias towards research dependent upon such equipment and neglect of other important research, not requiring the same level of infrastructure. Furthermore, the centralized groups of scientists may find it increasingly difficult to respond to the needs of managers spread across the country. Indeed, a tendency can occur for an emphasis in research upon problems in the region in which the centralized research facility is located, and neglect of problems in other regions.

The concern about centralization was expressed clearly in a submission by the Honourable G.R. McMahon (1984, 19), Minister of Community and Cultural Affairs for Prince Edward Island. In his words,

> "In hydrology, the province maintains contact with the National Hydrology Research Institute of Environment Canada. However, with a significant portion of the agency's work force devoted to other federal agencies, little groundwater research has been carried out in the Atlantic Region in the last several years.
>
> The planned transfer of this agency from Ottawa to Saskatoon in 1985-86 is further reason for concern. The feasibility of this agency conducting field research in the region becomes even more reduced".

These types of problems reinforce the need for a mechanism to plan and coordinate research activity at a national level.

2.3.4 Regional Issues

Water problems and issues vary from region to region across the country. The priority water issues in Atlantic Canada are not always identical to those of the Prairies, while issues in British Columbia often are different from those in Quebec. Regional differences in natural landscape, climate, settlement patterns and economic activity combine to generate a mix of problems. While some issues such as acid rain are significant for a number of regions, others are unique to specific regions or areas. This situation was mentioned frequently in the submissions to the Inquiry and by the experts consulted during this investigation of water research activity in Canada. It also was noted in the earlier reviews by Bruce and Maasland (1968) and Lefeuvre (1984).

The existence of different regional water issues and problems generates tension with respect to the trend towards centralization of research effort in federal laboratories and line agencies. As centralization is pursued, an increasing concern arises that the ability to respond to regional issues may be reduced. A major management problem therefore is to accommodate the presence of different regional problems while realizing economies of scale and benefits of interaction among scientists resulting from centralization of research activity.

2.3.5 Varying Perspectives

A variety of legitimate perspectives exist regarding research activity. Federal researchers often define their research work with reference to the mandates of their organizations. Provincial investigators take a similar perspective regarding their mandates. In the private sector, research is usually pursued to improve the efficiency of industrial processes or to develop new products or services which can be marketed on a commercial basis. Within the universities, research of a fundamental or pure nature may be pursued with funding from organizations such as NSERC or SSHRC, or may be done on a contract basis for government or the private sector.

In brief, the motivations for research may vary from sector to sector. Even if each group plans and coordinates its research activity in the interest of enhancing effectiveness within its sector, there is no assurance that an effective national strategy of research will emerge in the present situation, as there is no group responsible for considering the national perspective. In this context, a federal and national perspective are not synonymous. Nevertheless, the federal government should have a major role in helping to formulate and implement a coherent national strategy for water resources research.

2.4 CURRENT FUNDING LEVELS

2.4.1 Some Comments on Difficulties in Quantification

Although simple in concept, the quantification of the dollars associated with water resources research is extremely difficult. These difficulties arise for a number of reasons worth explaining briefly since frequent reference will be made in subsequent sections to the need to employ assumptions in the quantification of research efforts. The difficulties include:

(i) What is water research? The underlining emphasizes that the predominant concern is on water as the primary focus of the research. The difficulty in identifying water research is whether water is the primary focus, or whether, for example, it is insect research.

(ii) What is water research? The underlining emphasizes that the activity must involve research and not, for example, routine data collection. There is no control on how adequately this criterion was used during completion of the questionnaire by individual respondents. The concerns do not end here, however, in that information from some funding agencies only included individual project titles; it was necessary therefore to guess whether or not projects being funded qualify as research.

As well, indirect and overhead costs are difficult to quantify and to determine to what extent they should be included in research expenditures. These include administration and common services such as library, major common-user facilities and housing.

(iii) What is the category of research? To indicate the emphasis in direction of ongoing research, both within this study and for the previous studies (Bruce and Maasland (1969) and Lefeuvre (1984)), a series of categories of research have been identified. To allow for the characterization of trends that may be occurring with time, the same categories of research as used with the Lefeuvre study have been employed. Regardless, individual researchers frequently expressed considerable difficulty in assigning a particular category to their work with a common response that several categories were all applicable. Where more than a single category was noted in a questionnaire response, the approach adopted in the assignments to allow summations of the activity levels in the individual categories was simply to assume an equal distribution of effort within the categories specified.

(iv) To what degree is the "double-counting" of dollars a problem? This concern arises because several organizations may be reporting the same contract. For example, both the funding agency and the consultant doing the actual work, may list the same project. Obviously such a situation would overestimate the expenditures on research. The extent of any double-counting in the tables to follow is not felt to be appreciable, since considerable efforts were extended to eliminate this problem whenever sufficient information was provided to trace the dollar flows.

(v) Substantive responses from consultants were extremely minimal. This determination was very disappointing since it is only from the consultants themselves that an accurate assessment can be obtained of research funds obtained from other than federal agencies and selected provincial agencies (i.e. those which responded or publish annual reports). Since consultants claim they want to do more research, it is unfortunate to see how few deemed it worthwhile to indicate their interests and concerns through completion of the questionnaire.

(vi) Scale adjustments in research efforts were necessary because responses were not received summarizing all activities. The majority of the scaling undertaken was with NSERC operating grants -- a total of 1.5 million dollars was reported in the questionnaire responses, whereas 3.27 million dollars for water resources research were identified as being funded, from the NSERC file records Presuming that the reported university research funds from other sources (e.g. municipal, provincial, and industry) represented the same ratio as with the NSERC operating grants, these other sources of research revenue to the universities were also scaled by the ratio of 3.27/1.5 =2.18. Exceptions to the scaling were followed when reports were available on total fundings from a particular agency or organization (e.g. the Ontario Ministry of the Environment and the Donner Foundation); for these funds, the research expenditures were accepted as published.

(vii) Budget responses from universities did not include such dollar values as those of salary costs of professors, graduate student scholarships and overhead costs on many projects (e.g. those funded by NSERC).

The intent of the preceding is to indicate the types of difficulty of assignment of research dollars that are presented in the section to follow. The resulting tabulations represent the combination of analyses of questionnaire returns, contacts with individuals and agencies, examination of financial reports, etc. The data base is admittedly incomplete. Anyone in the field could, undoubtedly, identify specific omissions or incorrect characterizations. Refinements may always be made but within reasonable time and budget limitations and the appproximations indicated above, the findings are felt to be fairly representative of current research efforts in Canada.

Table 2.1 Research Source and Expenditure Dollars By Sectors of Research Community, 1983

Research Sector	Source ($ in 000's)	Source (% of Total)	Expenditures ($ in 000's)	Expenditures (% of Total)
Federal	40852.1	73.2	28190.1	50.5
Provincial	8985.7	16.1	7099.7	12.7
University	1447.8	2.6	14897.0	26.7
Industrial	2390.2	4.3	5632.4	10.1
Municipal	930.2	1.7	----	----
Foreign	305.8	.5	----	----
Other	907.2	1.6	----	----
Totals	55819.		55819.	

Table 2.2 Research Funds for Water Resources, Over Time

(Values in $000's)

Year	Research Funds in Given Year	Research Funds in 1983 Dollars*
1966 (Bruce/Maasland)	8389.	29640.
1979	52000.	75400.
1983		55820.

*using the consumer price index to update funding levels

Table 2.3 Changes With Time, of Percent of Total Funding By Source

Funding Sector	1966	1979	1983
	Year		
Federal	69.3	56.0	73.2
Provincial	17.3	29.6	16.1
University	10.1	2.7	2.6
Industry	3.3	11.6	4.3
Municipal	--	--	1.7
Foreign	--	--	.5
Other	--	--	1.6

Note - all values expressed in percents of total

Table 2.4 Changes With Time of Percent of Total Funding by Expenditure

Research Sector	1966	1979	1983
	Year		
Federal	44.4	41.1	50.5
Provincial	21.0	25.0	12.7
University	19.4	18.8	26.7
Industry	14.0	15.1	10.1

Note - all values expressed in percents of total

2.4.2 Source and Expenditure Levels of Research Monies

As an overall summary, the research dollars in relation to various research sectors are listed in Table 2.1 - the first column of values indicates the dollars provided by the research sector as the source of revenue, whereas the second column of values indicates the research expenditures by the respective research sector. As indicated by the last row of numbers, a total of 55.8 million dollars (1983) is expended on water-related research in Canada. The research funding is derived from a number of sources but the majority is from a very few.

An indication of the time-history of funding levels for water research is provided in Table 2.2 (the consumers price index was used for the updating). The indicated values present updated values to 1983 for the Bruce and Maasland and Lefeuvre studies. There is a substantial increase over 1966 funding but not at the levels which were recommended in the Bruce-Maasland report. In addition, a significant decrease in research funding in terms of 1983 dollars, is noted, from the 1979 study findings.

An examination of the funding levels by source as they have changed over time is interesting, with the various percentiles as indicated in Table 2.3. It would be inappropriate to attempt to draw too many conclusions from the figures but certainly some general trends are noteworthy:

(i) budgets available from universities as a source of research money have essentially disappeared;

(ii) industry contributions as a source of research money have increased; and,

(iii) the federal sector has continued to provide the greatest portion of the research funds available.

The changes with time of percent of total fundings as measured by expenditure, are indicated in Table 2.4. Given the uncertainty in the data, it is difficult to discern any significant trends although it appears there is an increasing role being filled by the federal sector while a decreasing role is being filled by the provincial sector.

Indications of the subject emphases of the funds provided by the various sources are summarized in Table 2.5. The sub-categories as included in Table 2.5 (and those to follow) have been chosen so as to coincide with those categories used in the previous studies.

As summary comments overall:

(i) support by federal research dollars is spread over all the sub-categories but 56 percent of the total is within the 500 series dealing fairly specifically with water quality concerns.

Table 2.5 Research lassified by Source (000$)

Code	Sub-categories	Fed.	Prov.	Univ.	Indy.	Foreign	Other	Total
101	Properties of Water	151.8	17.9	10.0	1.9	2.3	8.8	192.7
102	Aqueous Solutions and Suspensions	---	---	---	---	---	---	0.0
201	Water Cycle, General	830.5	59.8	23.4	43.9	6.0	7.0	980.5
202	Precipitation	252.0	---	---	---	---	---	252.0
203	Snow and Ice	2707.1	434.3	53.3	431.8	4.9	19.2	3650.5
204	Evaporation and Transpiration	45.6	4.4	2.3	0.2	---	3.0	55.5
205	Streamflow	440.9	336.3	16.2	2.6	3.7	14.2	813.8
206	Groundwater	2379.1	829.7	325.7	31.7	41.6	466.5	4074.4
207	Water in Soils	---	7.0	---	---	---	---	7.0
208	Lakes	1877.2	80.5	4.1	40.6	1.1	11.7	2015.2
209	Water and Plants	49.7	10.4	4.9	1.1	1.1	3.9	71.1
210	Erosion and Sedimentation	1156.6	458.0	45.4	64.3	10.1	78.5	1812.8
211	Chemical Processes	1022.2	302.4	16.7	2.6	3.8	14.5	1362.2
212	Estuarine Problems	215.0	46.9	20.0	2.8	4.0	15.4	304.0
301	Saline Water Conversion	125.7	---	---	45.7	---	---	171.4
302	Water Yield Improvement							0.0
303	Use of Water of Impaired Quality	175.1	97.4	22.1	3.5	5.0	19.2	322.2
304	Conservation in Domestic Use	65.9	17.8	9.1	1.4	2.0	32.7	128.9
305	Conservation in Industry							0.0
306	Conservation in Agriculture	432.2	158.3	59.2	6.3	9.1	5.0	700.1
307	Weather Modification	71.3	229.4	---	209.0	---	---	509.7
401	Control of Water on the Land	369.6	93.6	15.0	2.4	3.4	3.0	497.0
402	Groundwater Management	86.8	48.1	10.9	276.0	2.5	9.5	433.8
403	Effects of Man's Activities on Water	289.8	6.3	1.1	0.9	---	2.2	300.3
501	Identification of Pollutants	3010.2	530.1	104.3	21.1	12.4	49.5	3727.6
502	Sources and Fate of Pollution	7996.7	808.3	49.9	145.1	11.4	73.3	9084.7
503	Effects of Pollution	8832.6	2481.0	257.3	252.4	57.9	348.7	12229.9
504	Waste Treatment Processes	2336.4	246.3	17.8	68.6	2.9	11.1	2683.0
505	Ultimate Disposal of Wastes	100.5	303.9	21.0	7.1	3.7	14.3	450.6
506	Water Treatment	---	191.4	---	---	---	---	191.4
507	Water Quality Control	710.3	205.5	62.9	7.8	7.6	29.8	1024.0
601	Planning	300.8	66.1	74.7	304.6	3.5	24.5	774.2
602	Evaluation Processes	523.9	46.6	23.8	192.3	93.7	60.2	940.5
603	Cost Allocation, Sharing, Pricing	---	---	---	---	---	---	0.0
604	Water Requirements	170.1	4.5	2.3	0.6	---	2.9	180.4
605	Water Law	---	---	---	---	---	---	0.0
606	Institutional Aspects	90.4	12.3	4.5	1.1	1.1	156.5	266.0
607	Sociological and Psychological Aspects	121.8						121.8
608	Ecologic Impact of Water Development	327.4	5.6	1.9	7.5	---	155.2	497.7
701	Network Design	161.3	32.9	35.6	1.6	2.3	104.8	338.4
702	Data Acquisition	1742.4	309.1	15.3	160.6	2.5	10.7	2240.6
703	Evaluation, Processing and Publication	40.0	10.3	---	6.9	---	---	57.1
801	Specifications and Design	1287.4	438.1	73.7	44.1	6.3	26.4	1876.0
802	Materials	---	---	---	---	---	---	0.0
803	Operations	---	---	---	---	---	---	0.0
900	Environmental Health and Protection	355.7	35.4	63.5	---	---	5.5	460.1
	Total	40852.1	8985.7	1447.8	2390.2	305.8	1837.4	55819.0

(ii) support from provincial agencies is slightly less in terms of percent of total to water quality in the 500 series (53%), with considerable emphasis (29%) on the 200 series.

In a context similar to Table 2.5, the funds expended by the various research sectors within the sub-categories are summarized in Table 2.6. As apparent from the indicated dashes, certain types of research are not being pursued within some of the research sectors.

Summary information of the changes in emphasis of the research, as quantified by percentages within each of the 100's of the sub-categories, is provided in Table 2.7. Trends toward an increasing emphasis on water quality are apparent.

The expenditures on water resources research amounted to $56 million. While this expenditure may seem quite large, it amounts to only approximately $2.25 per Canadian citizen. To put this in a better comparison with other expenditures, expenditures on other concerns (in accord with Statistics Canada records) include:

	Expenses per Family (1983 $)
water	$ 78.8
electricity	$ 452.5
telephone	$ 354.9
laundry	$ 102.5
house insurance	$ 103.3
contents insurance	$ 55.1
health insurance	$ 225.0
cigarettes	$ 366.1
vehicle insurance	$ 382.0

Thus, while the expenditures on research may seem quite large, there exists a great need for more water research in Canada and the expenditures on research in comparison with other expenditures being made, are very small. Canadians are becoming more aware of the importance of water resources and will be looking to their governments for sound stewardship.

2.4.3 Distribution of Research Effort in Canada

The numbers of research projects classified by sector or agency of performance are provided in Table 2.8. It is readily apparent that the majority of research projects are undertaken within the federal sector, followed by universities, the provinces and lastly, the private sector.

2.4.4 Changes of Emphasis in Research Effort

Summarized in Table 2.9 are the percentages of the total water resources research expenditures within the different categories of research, as quantified over time. Some changes in emphasis are readily apparent whereby a decreased emphasis on the water cycle has occurred with an increased emphasis on quality management and protection. The remainder of the categories have remained essentially unchanged.

Table 2.6 Research Funds Classified by Expenditures (000$)

Code	Sub-categories	Fed.	Prov.	Univ.	Private	Operate	Capital	Total
101	Properties of Water	46.3	---	146.5	---	174.7	18.0	192.7
102	Aqueous Solutions and Suspensions	0.0	---	---	---	0.0	---	0.0
201	Water Cycle, General	660.0	---	274.3	46.3	944.0	36.5	980.5
202	Precipitation	190.9	27.4	33.7	---	252.0	---	252.0
203	Snow and Ice	2313.4	630.3	325.0	381.9	3396.3	254.0	3650.3
204	Evaporation and Transpiration	21.7	---	33.8	---	47.0	8.5	55.5
205	Streamflow	162.5	382.6	236.7	32.0	811.1	2.7	813.8
206	Groundwater	264.9	1073.1	2672.3	64.1	3973.8	100.6	4074.4
207	Water in Soils	---	4.9	---	22.1	27.0	---	27.0
208	Lakes	1677.4	65.7	60.4	211.7	1957.7	57.5	2015.2
209	Water and Plants	---	---	71.1	---	71.1	---	71.1
210	Erosion and Sedimentation	698.8	356.6	663.1	94.3	1778.3	34.5	1812.8
211	Chemical Processes	772.5	346.3	243.4	---	1325.0	37.2	1362.2
212	Estuarine Problems	---	---	258.3	45.7	301.0	3.0	304.0
301	Saline Water Conversion	---	---	---	171.4	130.0	41.4	171.4
302	Water Yield Improvement	---	---	---	---	0.0	---	0.0
303	Use of Water of Impaired Quality	---	---	322.2	---	316.2	6.0	322.2
304	Conservation in Domestic Use	---	---	128.9	---	127.9	1.0	128.9
305	Conservation in Industry	---	---	---	---	0.0	---	0.0
306	Conservation in Agriculture	---	---	581.8	118.3	685.3	14.8	700.1
307	Weather Modification	---	509.7	0.0	---	477.7	32.0	509.7
401	Control of Water on the Land	186.3	19.4	218.3	72.9	469.0	28.0	497.0
402	Groundwater Management	---	---	159.5	274.3	283.8	150.0	433.8
403	Effects of Man's Activities on Water	277.5	---	22.8	---	287.3	13.0	300.3
501	Identification of Pollutants	2587.6	156.6	933.3	50.2	3384.3	343.0	3727.6
502	Sources and Fate of Pollution	7354.2	647.7	761.1	321.7	8664.3	420.4	9084.7
503	Effects of Pollution	6418.1	1823.9	3857.1	130.7	11629.8	600.1	12229.9
504	Waste Treatment Processes	2194.2	197.1	96.3	195.4	2673.0	10.0	2683.0
505	Ultimate Disposal of Wastes	---	142.4	239.7	68.6	443.6	7.0	450.6
506	Water Treatment	---	105.7	---	85.7	180.7	10.7	191.4
507	Water Quality Control	385.1	114.3	490.7	33.8	1011.0	13.0	1024.0
601	Planning	---	---	398.7	375.5	727.3	46.9	774.2
602	Evaluation Processes	---	1.1	385.8	553.6	939.5	1.0	940.5
603	Cost Allocation, Sharing, Pricing	---	---	---	---	0.0	---	0.0
604	Water Requirements	146.3	---	34.1	---	180.4	---	180.4
605	Water Law	---	---	0.0	---	0.0	---	0.0
606	Institutional Aspects	---	---	112.8	153.1	266.0	---	266.0
607	Sociological and Psychological Aspects	---	---	73.0	48.8	121.8	---	121.8
608	Ecologic Impact of Water Development	304.0	---	34.8	158.9	489.7	8.0	497.7
701	Network Design	28.6	94.9	215.0	---	335.3	3.1	338.4
702	Data Acquisition	1176.1	400.0	144.4	520.1	1950.7	289.9	2240.6
703	Evaluation, Processing and Publication	---	---	---	57.1	56.1	1.0	57.1
801	Specifications and Design	49.1	---	482.6	1344.3	1845.0	31.0	1876.0
802	Materials	---	---	---	---	0.0	---	0.0
803	Operations	---	---	---	---	0.0	---	0.0
900	Environmental Health and Protection	274.7	---	185.6	---	459.8	0.5	460.3
	Total	28190.1	7099.7	14897.0	5632.4	53174.8	2644.3	55819.1

Table 2.7 Comparison Between 1966, 1979 and 1983 Research Funds Classified by Source

Funding Sector		Category 100	200	300	400	500	600	700	800	900	Total
Federal	1966	87	9700	1350	800	5235	800	1250	1335	0	20530
	1979	450	9920	710	1030	21050	1320	1680	2335	3785	42280
	1983	152	10976	870	746	22987	1534	1944.	1287	356	40852
Provincial	1966	0	3335	145	245	1030	130	220	30	0	5135
	1979	230	5050	60	2235	6540	260	1045	420	6500	22330
	1983	18.	2570	503	148	4767	135.	352	438	35	8986
Industry	1966	60	90	15	0	2480	0	45	320	0	3000
	1979	0	1740	30	30	2525	115	160	2550	1625	8770
	1983	2.	622.	266.	279.	502.1	506.	169	44	0	2390.
University	1966	0	710	15	0	160	60	0	30	0	970
	1979	0	915	45	0	390	90	410	115	60	2015
	1983	10	512.	90.	27.	513	107	51	74	64	1448
Total	1966	145	13820	1520	1045	8905	985	1510	1710	0	29640
	1979	680	17620	840	3290	30510	1785	3290	5425	11960	75400.
	1983	193.	15399	1832	1231	29391	2781	2636.	1876	460.1	55819

Table 2.8 Number of Research Projects Classified by Agency of Performance

Code	Sub-categories	Fed.	Pr	Mun.	Private	Univ.	Non-Prof.	Total
101	Properties of Water	2	---	---	---	3	---	5
102	Aqueous Solutions and Suspensions	---	---	---	---	---	---	---
201	Water Cycle, General	19	---	---	1	7	---	27
202	Precipitation	1	---	---	---	---	---	1
203	Snow and Ice	13	7	---	2	8	---	30
204	Evaporation and Transpiration	4	---	---	---	1	---	5
205	Streamflow	3	4	---	---	6	---	13
206	Groundwater	8	9	---	---	30	---	47
207	Water in Soils	---	1	---	1	---	---	2
208	Lakes	12	2	---	---	2	---	16
209	Water and Plants	---	---	---	---	3	---	3
210	Erosion and Sedimentation	12	3	---	1	5	---	21
211	Chemical Processes	1	4	---	---	4	---	9
212	Estuarine Problems	1	---	---	1	4	---	6
301	Saline Water Conversion	---	---	---	2	---	---	2
302	Water Yield Improvement	---	---	---	---	---	---	--
303	Use of Water of Impaired Quality	---	---	---	---	1	---	1
304	Conservation in Domestic Use	---	---	---	---	4	---	4
305	Conservation in Industry	---	---	---	---	---	---	--
306	Conservation in Agriculture	---	---	---	---	6	---	6
307	Weather Modification	1	---	---	---	---	---	1
401	Control of Water on the Land	1	1	---	1	2	---	5
402	Groundwater Management	---	1	---	1	4	---	6
403	Effects of Man's Activities on Water	4	---	---	---	---	---	4
501	Identification of Pollutants	15	4	---	---	9	---	28
502	Sources and Fate of Pollution	54	12	---	1	14	---	81
503	Effects of Pollution	44	6	---	---	19	---	69
504	Waste Treatment Processes	---	5	---	2	2	---	9
505	Ultimate Disposal of Wastes	---	3	---	---	3	---	6
506	Water Treatment	---	3	---	---	3	---	6
507	Water Quality Control	3	1	---	---	10	---	14
601	Planning	---	---	---	2	10	---	12
602	Evaluation Processes	---	2	---	2	3	---	7
603	Cost Allocation, Sharing, Pricing	---	---	---	---	---	---	--
604	Water Requirements	1	---	---	---	2	---	3
605	Water Law	---	---	---	---	---	---	--
606	Institutional Aspects	---	---	---	---	4	---	4
607	Sociological and Psychological Aspects	---	---	---	---	---	---	--
608	Ecologic Impact of Water Development	2	---	---	1	1	---	4
701	Network Design	---	2	---	---	4	---	6
702	Data Acquisition	11	1	---	1	4	---	17
703	Evaluation, Processing and Publication	---	---	---	1	1	---	2
801	Specifications and Design	1	---	---	3	9	---	13
802	Materials	---	---	---	---	---	---	--
803	Operations	---	---	---	---	---	---	--
900	Environmental Health and Protection	5	---	---	---	---	---	5
	Total	218	71	---	23	188	---	500

Note - in some situations only reported research dollars were provided, but no indication of the number of projects being undertaken. As a consequence, there are projects which are not included in the above table

Table 2.9 Percentage of Effort Within Different Categories of Research

(all values in percent of total)

Category		1966	1979	1983
100	Nature of Water	.5	.5	.3
200	Water Cycle	47.	24.	27.6
300	Supply Augmentation and Conservation	5.	1.	3.3
400	Quantity Management and Control	4.	4.5	2.2
500	Quality Management and Protection	30.	40.5	52.7
600	Economic, Social and Institutional Aspects	3.	2.	5.0
700	Resources Data	5.	4.5	4.7
800	Engineering Works	5.5	7.	3.4
900	Environmental Management and Protection	na	16.	.8

Note - na category not included in 1966 study

2.4.5 Geographical Distribution of Research Effort Within Canada

Indications of the geographical distribution of the water research effort in Canada are provided in Tables 2.10 and 2.11 where the number of water research projects being carried out in each province (and Ottawa) and the research expenditures being made within each province (and Ottawa), respectively, are provided. It is readily apparent that the majority of research efforts are currently being carried out in Ontario. On the other hand, the emphasis on more regionally-specific aspects of water resources are being pursued in specific locales, viz the classes of 300 (Supply Augmentation and Conservation) and 400 (Quantity Management and Control).

It is to be noted there are projects which could not be assigned due to a lack of information available to the study - e.g., only reported research dollars expended by an agency but not the geographical location at which the expenditures are made. Thus, the numbers reported in Table 2.10 are definitely on the low side.

2.4.6 NSERC Funding Levels by Discipline

NSERC continues to be the major source of funding for water resources research at universities. As estimated within this study, 31 percent of the total funding of water resources research at universities was obtained from general NSERC grants. In addition, 16 percent of total funding of water resources research at universities was obtained from the Strategic Grants program of NSERC. Thus, NSERC alone provides 47 percent of the funding for water resources research at universities in Canada.

The departmental distribution of the NSERC monies is indicated in Table 2.12 for Grants and in Table 2.13 for Strategic Grants. The tabulated information indicates how the Strategic Grant research dollars are being directed in larger grants, in comparison with the general NSERC grants (the Strategic Grants being approximately 43400/18700 = 2.3 times as large). The intent in the Strategic Grants program to direct larger grants toward priority areas is obviously being pursued.

2.4.7 Funding Through the Department of Supply and Services

Funding agencies, in combination with Department of Supply and Services (DSS), represent a significant component of research directed in particular to the private or industry sector. An indication of the funding role of DSS is provided by the data summarized in Table 2.14.

Several remarks may be made:

(i) DSS funding by the unsolicited proposal route provides a valuable opportunity for supporting innovative work, since the incentive at least in part, encourages individuals and organizations to be innovative in their unsolicited proposals;

Table 2.10 Number of Water Research Projects Performed in Each Province (and Ottawa)

Code	Sub-categories	B.C.	Alta.	Sask.	Man.	Ont.	Ott.	Que.	N.B.	N.S.	P.E.I.	Nfld.	Total
101	Properties of Water	--	--	--	--	3	2	--	--	--	--	--	5
102	Aqueous Solutions and Suspensions	--	--	--	--	--	--	--	--	--	--	--	--
201	Water Cycle, General	1	--	--	2	4	18	--	1	1	--	--	27
202	Precipitation	--	--	--	--	1	--	--	--	--	--	--	1
203	Snow and Ice	2	3	1	--	10	9	--	5	--	--	--	30
204	Evaporation and Transpiration	--	--	--	--	1	4	--	--	--	--	--	5
205	Streamflow	--	4	--	1	7	1	--	--	--	--	--	13
206	Groundwater	--	2	6	--	30	7	--	1	--	1	--	47
207	Water in Soils	--	--	--	--	2	--	--	--	--	--	--	2
208	Lakes	1	1	--	--	13	--	1	--	--	--	--	16
209	Water and Plants	--	--	--	1	2	--	--	--	--	--	--	3
210	Erosion and Sedimentation	4	2	--	3	10	2	--	--	--	--	--	21
211	Chemical Processes	--	--	1	1	3	--	1	3	--	--	--	9
212	Estuarine Problems	1	--	--	--	1	--	--	--	4	--	--	6
301	Saline Water Conversion	2	--	--	--	--	--	--	--	--	--	--	2
302	Water Yield Improvement	--	--	--	--	--	--	--	--	--	--	--	--
303	Use of Water of Impaired Quality	--	--	--	1	--	--	--	--	--	--	--	1
304	Conservation in Domestic Use	--	--	--	--	4	--	--	--	--	--	--	4
305	Conservation in Industry	--	--	--	--	--	--	--	--	--	--	--	--
306	Conservation in Agriculture	--	--	--	3	--	--	3	--	--	--	--	6
307	Weather Modification	--	--	1	--	--	--	--	--	--	--	--	1
401	Control of Water on the Land	--	1	--	1	2	1	--	--	--	--	--	5
402	Groundwater Management	--	1	--	--	--	--	5	--	--	--	--	6
403	Effects of Man's Activities on Water	--	--	--	--	3	1	--	--	--	--	--	4
501	Identification of Pollutants	--	2	--	3	22	--	--	--	1	--	--	28
502	Sources and Fate of Pollution	--	3	--	10	57	9	--	1	1	--	--	81
503	Effects of Pollution	2	1	--	9	57	--	--	--	--	--	--	69
504	Waste Treatment Processes	1	--	--	--	8	--	--	--	--	--	--	9
505	Ultimate Disposal of Wastes	1	3	1	--	1	--	--	--	--	--	--	6
506	Water Treatment	--	1	1	--	3	--	--	--	--	--	--	5
507	Water Quality Control	1	--	--	9	4	--	--	--	--	--	--	14
601	Planning	3	--	--	4	5	--	--	--	--	--	--	12
602	Evaluation Processes	--	1	--	1	5	--	--	--	--	--	--	7
603	Cost Allocation, Sharing, Pricing	--	--	--	--	--	--	--	--	--	--	--	--
604	Water Requirements	--	--	--	--	2	1	--	--	--	--	--	3
605	Water Law	--	--	--	--	--	--	--	--	--	--	--	--
606	Institutional Aspects	--	--	--	--	4	--	--	--	--	--	--	4
607	Sociological and Psychological Aspects	--	--	--	--	--	--	--	--	--	--	--	--
608	Ecologic Impact of Water Development	--	1	--	1	1	--	--	--	--	1	--	4
701	Network Design	--	--	--	--	6	--	--	--	--	--	--	6
702	Data Acquisition	--	--	1	--	9	6	--	--	--	--	--	16
703	Evaluation, Processing and Publication	--	--	--	1	1	--	--	--	--	--	--	2
801	Specifications and Design	2	1	--	1	5	--	3	--	1	--	--	13
802	Materials	--	--	--	--	--	--	--	--	--	--	--	--
803	Operations	--	--	--	--	--	--	--	--	--	--	--	--
900	Environmental Health and Protection	--	--	--	--	5	--	--	--	--	--	--	5
	Total	21	27	12	52	291	61	13	11	8	2	--	498

Note - in some situations only reported research dollars were provided, but no indication of the number of projects being undertaken. As a consequence, there are projects which are not included in the above table.

Table 2.11 Research Expenditures in Each Province (percentages)

Code	Sub-categories	B.C.	Alta.	Sask.	Man.	Ont.	Ott.	Oue.	N.B.	N.S.	P.E.I.	Nfld.
101	Properties of Water	--	--	--	--	58	42	--	--	--	--	--
102	Aqueous Solutions and Suspensions	--	--	--	--	--	--	--	--	--	--	--
201	Water Cycle, General	3	--	--	17	10	67	--	3	--	--	--
202	Precipitation	--	--	--	--	--	100	--	--	--	--	--
203	Snow and Ice	7	18	2	--	16	47	--	9	--	--	--
204	Evaporation and Transpiration	--	--	--	--	40	60	--	--	--	--	--
205	Streamflow	--	46	--	1	37	16	--	--	--	--	--
206	Groundwater	--	11	29	--	46	11	--	.5	--	3	--
207	Water in Soils	--	--	--	--	100	--	--	--	--	--	--
208	Lakes	15	5	--	--	84	1	1	--	--	--	--
209	Water and Plants	--	--	--	37	63	--	--	--	--	--	--
210	Erosion and Sedimentation	11	21	--	11	56	2	--	--	--	--	--
211	Chemical Processes	--	--	1	64	6	--	2	27	--	--	--
212	Estuarine Problems	29	--	--	--	--	--	--	--	71	--	--
301	Saline Water Conversion	100	--	--	--	--	--	--	--	--	--	--
302	Water Yield Improvement	--	--	--	--	--	--	--	--	--	--	--
303	Use of Water of Impaired Quality	--	--	--	100	--	--	--	--	--	--	--
304	Conservation in Domestic Use	--	--	--	--	100	--	--	--	--	--	--
305	Conservation in Industry	--	--	--	--	--	--	--	--	--	--	--
306	Conservation in Agriculture	--	--	--	69	--	--	31	--	--	--	--
307	Weather Modification	--	--	100	--	--	--	--	--	--	--	--
401	Control of Water on the Land	--	6	--	21	17	56	--	--	--	--	--
402	Groundwater Management	--	80	--	--	--	--	20	--	--	--	--
403	Effects of Man's Activities on Water	2	--	--	--	84	13	--	--	--	--	--
501	Identification of Pollutants	--	4	--	9	86	--	--	--	.1	--	--
502	Sources and Fate of Pollution	--	1	3	11	76	8	--	.4	.1	.5	--
503	Effects of Pollution	6	.9	3	23	66	--	--	--	--	--	--
504	Waste Treatment Processes	21	--	--	--	79	--	--	--	--	--	--
505	Ultimate Disposal of Wastes	18	45	15	--	22	--	--	--	--	--	--
506	Water Treatment	--	18	--	--	82	--	--	--	--	--	--
507	Water Quality Control	3	--	--	66	30	--	--	--	--	--	--
601	Planning	8	--	--	79	14	--	--	--	--	--	--
602	Evaluation Processes	--	47	--	8	44	--	--	--	--	--	--
603	Cost Allocation, Sharing, Pricing	--	--	--	--	--	--	--	--	--	--	--
604	Water Requirements	--	--	--	--	9	91	--	--	--	--	--
605	Water Law	--	--	--	--	--	--	--	--	--	--	--
606	Institutional Aspects	--	--	--	--	100	--	--	--	--	--	--
607	Sociological and Psychological Aspects	--	--	--	--	--	--	--	--	--	--	--
608	Ecologic Impact of Water Development	--	5	--	91	2	--	--	--	2	--	--
701	Network Design	--	--	--	--	100	--	--	--	--	--	--
702	Data Acquisition	--	--	32	--	60	7	--	--	--	--	--
703	Evaluation, Processing and Publication	--	--	--	40	60	--	--	--	--	--	--
801	Specifications and Design	5	58	--	8	23	--	6	--	--	--	--
802	Materials	--	--	--	--	--	--	--	--	--	--	--
803	Operations	--	--	--	--	--	--	--	--	--	--	--
900	Environmental Health and Protection	--	--	--	--	100	--	--	--	--	--	--

Table 2.12 Distribution of Grants for Water Research As Funded by NSERC, 1983

Department	Number of Grants	Monies to Grants: Average Size ($)	Monies to Grants: Standard Deviation ($)	Total ($000's)
Civil Engineering	90	16922	6513	1523
Geography and Agric. Engineering	13	14370	7197	187
Oceanography	13	24999	9915	325
Biology/Chemistry/ Botany/Zoology	42	22905	15385	962
Mathematics/Physics/ Earth Sciences	17	15770	11873	268
				Total = $ 3,265

Notes - figures quoted for fiscal year 1983/84
- some latitude has been used in rounding-off the number in the above table so as not to imply unwarranted precision.

Table 2.13 Distribution of Strategic Grants for Water Research as Funded by NSERC

Department	Number of Strategic Grants	Monies to Grants: Average Size ($)	Monies to Grants: Standard Deviation ($)	Total ($000's)
Chemistry/Biology/ Botany/Zoology	20	38745	5296	774.9
Civil Engineering	9	49722	5494	447.5
Oceanography	7	46586	5004	326.1
Mathematics/Physics/ Earth Sciences	3	48267	4176	144.8
Totals	39			1693.3

Table 2.14 DSS Summary of Water Research Funded Projects (in 1983)

Federal Department Source	Research Dollars to Private Sector (000's)	Research Dollars to Universities (000's)
Environment	872.4	186.8
Fisheries & Oceans	527.2	13.6
Energy, Mines & Resources	197.1	35.8
International Joint Commission	51.1	---
National Research Council	703.4	105.2
Transportation	130.0	---
AECB	23.0	---
Agriculture	103.5	---
Sub totals	2607.7	341.4

(ii) DSS funding, in combination with the bridge funding required from the sponsoring department, represents an important opportunity to direct research efforts toward designated, priority areas.

(iii) on the negative side, sponsoring departments have historically had great difficulty in providing even the modest bridging funds required (typically fifteen percent of the total budget), since this type of funds are in extremely short supply (as indicated within both the interview and questionnaire responses).

(iv) there is bidding amongst departments of the federal government for research monies, with the research money going to universities, if obtained. These funds provide financial support for topics of federal priority.

2.4.8 Research Effort by Educational Levels

Of interest for future personnel needs are the varying requirements for different educational levels. Unfortunately, many of the submitted questionnaires were incomplete, making it impossible to get an accurate determination. However, presuming those questionnaires received are a random set of submissions, then the relative numbers of individuals of varying educational levels involved in research within the sub-categories should indicate the areas of current, greatest involvement. The information available in the questionnaires is summarized in Table 2.15 which indicates the man-years of research effort classified by educational level.

Information on professional staff additions and deletions as reported was rather incomplete -- only specific examples are available.

Specifically:

(i) NHRI - no major staff changes are planned (the addition of 7 by 1985),

(ii) NWRI - no staff changes planned,

(iii) Freshwater Institute - only 10 additional staff planned by 1985.

It is also worthy of note that there are no full-time research scientists in NWRI who will be younger than 35 at the end of 1985 and that 60 percent of the scientists are between the ages of 40 and 49. All of this does not bode well for employment opportunities in the above organizations. Further comments on research personnel and continuing education are contained in Section 3.2.7.

Other submitted information was not in a form for which viable projections could be made. Few additions are expected with current funding levels.

Table 2.15 Man-Years of Research Effort Classified by Educational Level

Code	Sub-categories	Doctor	Master	Bachelor	Student	Technician	Total
101	Properties of Water..................................	3.2	1.	.2	---	.4	4.8
102	Aqueous Solutions and Suspensions..................	---	---	---	---	---	---
201	Water Cycle, General................................	8.5	7.4	1.6	.9	4.2	22.6
202	Precipitation..	---	---	---	---	---	---
203	Snow and Ice...	21.9	13.4	9.7	1.	11.1	57.1
204	Evaporation and Transpiration.......................	3.	.5	.3	.2	.1	4.1
205	Streamflow...	2.5	5.2	2.4	1.0	6.6	17.7
206	Groundwater..	3.4	8.0	5.1	---	6.8	23.3
207	Water in Soils.......................................	---	---	.1	---	---	.1
208	Lakes..	7.8	1.2	7.9	---	3.4	20.3
209	Water and Plants.....................................	.5	---	---	---	---	.5
210	Erosion and Sedimentation...........................	6.2	5.6	2.6	3.6	5.4	23.4
211	Chemical Processes...................................	3.4	4.9	4.1	2.6	4.2	19.2
212	Estuarine Problems...................................	2.3	.1	3.4	10.	---	15.8
301	Saline Water Conversion.............................	.5	---	2.	---	---	2.5
302	Water Yield Improvement.............................	---	---	---	---	---	---
303	Use of Water of Impaired Quality....................	.2	---	2.	2.	---	4.2
304	Conservation in Domestic Use........................	.2	---	.9	---	.2	1.3
305	Conservation in Industry............................	---	---	---	---	---	---
306	Conservation in Agriculture.........................	1.1	3.2	4.	2.1	4.	14.4
307	Weather Modification................................	3.	1.	1.	---	3.	8.
401	Control of Water on the Land........................	4.	3.6	1.9	---	.7	10.2
402	Groundwater Management..............................	1.2	.2	.4	1.	.5	3.3
403	Effects of Man's Activities on Water...............	.7	3.	1.	.3	1.9	6.9
501	Identification of Pollutants........................	15.6	3.5	3.7	---	13.2	36.
502	Sources and Fate of Pollution.......................	28.4	12.2	19.6	1.2	35.5	96.9
503	Effects of Pollution................................	39.6	24.4	23.8	14.1	21.1	123.
504	Waste Treatment Processes...........................	.5	.7	.2	.5	.8	2.7
505	Ultimate Disposal of Wastes.........................	1.8	.5	1.9	1.1	.8	6.1
506	Water Treatment......................................	.5	.2	.2	.1	.2	1.2
507	Water Quality Control...............................	5.0	5.4	9.5	6.5	5.2	31.6
601	Planning...	1.3	3.7	2.	---	.5	7.5
602	Evaluation Processes................................	.4	---	.4	---	.2	1.
603	Cost Allocation, Sharing, Pricing..................						---
604	Water Requirements..................................	1.	---	.3	---	---	1.3
605	Water Law..	---	---	---	---	---	---
606	Institutional Aspects...............................	1.	---	---	.4	---	1.4
607	Sociological and Psychological Aspects.............	---	---	---	---	---	---
608	Ecologic Impact of Water Development...............	1.6	.2	---	.1	.5	2.4
701	Network Design.......................................	---	.6	---	---	---	.6
702	Data Acquisition.....................................	1.3	1.7	1.3	.2	3.9	8.4
703	Evaluation, Processing and Publication.............	---	.4	.9	---	2.4	3.7
801	Specifications and Design...........................	3.8	6.5	3.	.3	2.1	15.7
802	Materials..	---	---	---	---	---	---
803	Operations...	---	---	---	---	---	---
900	Environmental Health and Protection................	.3	1.3	---	---	.3	1.9
	Total...........................	175.7	120.	117.4	50.2	140.2	603.5

Note - in some situations only reported research dollars were provided, but no indication of man-years by educational level were indicated. As a consequence, the above should be considered as lower bounds.

2.5 Examples of Funding Patterns

The previous discussion has provided an overview of water research activity and effort at an aggregate level. In this section, attention is focussed upon two organizations to illustrate the way in which the general trends and patterns manifest themselves within specific organizations.

2.5.1 National Water Research Institute

The National Water Research Institute (NWRI) represents a major component of the water research effort in Canada. Specifically, the Institute carries out a program of research and development designed to meet the objective of providing the necessary information and understanding of water systems for water management problems or opportunities in Canada.

Due to the leading role of NWRI in water research in Canada, a request was made of Dr. G.K. Rodgers, Director of NWRI, to quantify personnel and budget expenditures that have occurred over recent years. The response included the person-year resources as quantified in Table 2.16. From the tabulated figures it is apparent that core staffing is reducing while other staff resources (so-called "soft" sources because of their temporary nature) have remained fairly steady with a small increase in 1984/85. Overall, there has been a slight decrease with time.

The trends in capital and operations and maintenance (O&M) budgets are provided in Table 2.17. The bracketed values following individual entries represent adjusted values to 1983/84 fiscal year dollars using a consumers price index. Noteworthy points regarding the indicated values include:

(i) O&M reported values do not include salaries,

(ii) the values in capital trends are largely all in research with approximately $160 k to $200 k being used in support of field operations and calibration/assurance services. The variations in the levels for supplementary capital are directly attributable to specific initiatives, and explain much of the variability in the total funding levels, the last row in the table;

(iii) the O&M A-base is subdivided into building/administration and research/R.S.A. Noteworthy is that building and administration costs have increased whereas research allocations have decreased, with the total O&M A-base dollars remaining essentially constant;

(iv) supplementary funding to O&M is variable from year to year. These funds are a measure of direct support from NWRI clients including Canadian Climate Program, Program for Energy R&D, Great Lakes Water Quality Program (special allocation to Regional Director General), Toxic Chemicals Management Program and Long Range Transport of Airborne Pollutants.

Table 2.16 NWRI Person-Year Resources

	Fiscal Year			
	1981/82	1982/83	1983/84	1984/85
Regular Staffing	262	260	254	250
Others ("soft sources")	8.5	7.5	8.9	11.75
Grand Totals	270.5	267.5	262.9	261.75

Table 2.17 NWRI Funding Trends

	Fiscal Year				
	1980/81	1981/82	1982/83	1983/84	1984/85
Capital Trends					
Core A-Base Capital	903(1189)	982(1151)	1324(1401)	1461(1461)	1407(1349
Supplementary Capital	255(336)	938(1100)*	243(257)	714(714)**	196(188)
O&M Resource Trends (salaries not included)					
Building & Administration	1615(2128)	2046)2398)	2280(2413)	2503(2503)	2760)2646
Research and R.S.A.	2166(2854)	2153(2590)	2428(2569)	2384(2384)	2369(2272
Total A-Base	3781(4982)	4199(4922)	4708(4982)	4887(4887)	5129(4918
Supplementary Funding	740(975)	1259(1476)	934(988)	1483(1483)	980(940)
Totals	5679(7482)	7378(8649)	7209(7628)	8545(8545)	7712(7395

Notes - all budget values in $000's

- bracketed values are estimated 1983/84 dollar values using the consumers price index as an adjustment factor

* major toxic chemical instrumentation program

** renovation of water quality lab/WQB centralization at CCIW

The most important finding from the above information is that with respect to both person-years and research dollars, the resources available to NWRI are decreasing with time. Since NWRI is definitely a leading agency for water research in Canada, this finding is distressing.

2.5.2 Westwater Research Centre, University of British Columbia, Vancouver

The Westwater Research Centre is a part of the Faculty of Graduate Studies at the University of British Columbia. Its role is "to carry out studies of policies and methods of managing natural resources" (Westwater Research Centre, 1984). Its research program currently has several thrusts including coastal resources of British Columbia, water quality management, northern water resources planning, and international water resources management. To conduct its work, Westwater has a permanent staff of university professors and research associates with expertise in law, planning, economics, political science, geography, marine ecology, fisheries, biology, and environmental chemistry. Although the University of British Columbia now pays for the core budget of the Westwater staff, "it is intended that Westwater be as self-supporting as possible and, therefore, that its project budgets cover staff time as well as travel, office and publishing expenditures" (Westwater Research Centre, 1984).

Westwater was one of six university programs across the nation to receive development support from the Inland Waters Directorate in the early 1970's. The intent was to encourage and develop different aspects of water research expertise in various regions of the country. Westwater was established in September, 1971, with a development grant of $90,000 provided by the Inland Waters Directorate of Environment Canada. In the second year of operation (1972-1973), half of the first grant was carried over to be combined with a second grant of $180,000 from Environment Canada. In the first two years of operations, Environment Canada was the only source of funds for Westwater and the research focussed upon water quality in the Lower Fraser River.

During 1973-1974, Westwater received a third grant of $180,000 from Environment Canada. However, other funding also was obtained, with $25,000 received from the Rockefeller Foundation in August 1973 to support research on international river basin developments (Ross Dam on the Skagit River, Columbia River Treaty between Canada and the United States; pollution of the Rhine River, shared by Switzerland, West Germany, France and the Netherlands).

By 1974-1975, the development grant funding from Environment Canada was decreased to $157,000. However, funding sources were becoming diversified. The first contractual work for Environment Canada generated $22,500. A Canada Council grant of $33,360 was received for institutional studies regarding the Fraser River. Summer student funds from the federal and British Columbia governments allowed students to supplement the staff. In addition, the first funds ($16,000) from the province supported a conference, and funds ($10,690) from the Vancouver Foundation allowed continuation of a lecture series which had been initiated with earlier Environment Canada funding.

The year 1974-1975 also was significant in that the University of British Columbia began to fund the core staff at Westwater with $10,197. In 1975-1976, the University increased its core funding to $60,870, which was the beginning of a financial arrangement under which core staff held joint appointments in Westwater and an academic department. By 1984-1985, the six academic core staff each had a portion of their salary ranging from 25 to 80 percent provided through Westwater with the balance coming from departments or schools as diverse as Law, Community and Regional Planning, Civil Engineering, Forestry, Soil Science, and the Institute of Animal Resource Ecology. It has been suggested that "the continuing commitment of the University to a core capability has been a major factor in determining Westwater's success" (Dorcey, 1985, 2).

During 1975-1976, the Lower Fraser Pollution Control Program, which had been the major activity funded under the Development Grant program of Environment Canada, came to a conclusion. A new initiative focussed upon coastal resource management, with particular regard to estuaries. By 1976-1977 the funding from Environment Canada fell to $88,000, and support from the University increased to $93,000. In that year, $40,000 provided by the Rockefeller Foundation facilitated further research on the management of international rivers.

The next year was devoted to preparing a major proposal to Canada Council for a negotiated development grant to support an integrated set of natural and social science studies on coastal resources. This proposal was unsuccessful, and led to some fundamental decisions regarding the type of research Westwater would pursue. As the Assistant Director (Dorcey, 1985, 2) explained:

> "It was at this point that we concluded that we would never be able to convince the Councils to fund applied public policy research that integrated both the natural and the social sciences (this has continued to be our experience with several subsequent submissions to NSERC and SSHRC). We decided that we would have to adopt a strategy of piecemeal funding the components wherever possible and then integrating them as best as possible as part of the conduct of the research. This is why you see a more diverse program and variety of funding sources in the years following".

This recognition of restraints upon funding for interdisciplinary and/or non-traditional research activity also led to termination of a quarterly newsletter and the annual Westwater Lectures Series. These highly successful extension activities had been conceived as mechanisms to inform managers and the general public about the results and implications of research at Westwater. However, despite the occasional special newsletter and one further lecture series, the Centre had to rely upon its own publication series as well as publishing in journals to disseminate research findings and conclusions.

Funding from Environment Canada continued, but on a decreasing level of support: \$88,000 in 1977-1978; \$60,000 in 1978-1979; and \$22,000 in 1979-1980. Funding from the Inland Waters Directorate continued to trail off and after 1982-1983 Westwater stopped applying for support. At the same time, other sources were pursued. Projects and funding sources became diverse: mariculture research supported by British Columbia; pollution control in the Fraser River with funds from the National Research Council; international water management in Africa under the Ford Foundation, Rockefeller Foundation and Resources for the Future; environmental regulations for the Economic Council of Canada; a training and research program in Peru through the Canadian International Development Agency; the continuation of coastal and northern research programs supported by a variety of sources including the Max Bell and Donner foundations.

A key point which emerges is the time and effort which the staff at Westwater devote to the discussion, preparation and presentation of research proposals starting in the mid 1970's. Since rarely would one funding agency consider an application which was applied, policy-oriented, and interdisciplinary, many smaller proposals had to be prepared which addressed the mandates or interests of sponsors. When some of the proposals were not funded, then it became difficult for the pieces to be integrated.

Notwithstanding the continuous tension created by the need to obtain funding, Westwater has been one of the most successful of the research centres which were started in the early 1970's by seed money provided through the Inland Waters Directorate of Environment Canada. It continues to operate an active and sustained research program, whereas other initiatives such as the Agassiz Centre at the University of Manitoba have been closed. Westwater has received substantial funds from the federal and provincial governments, private firms, and foundations. Its publication program has been substantial, with some 18 books and 28 reports listed in its publication guide. In addition, numerous chapters in books and articles in periodicals have been published by the researchers at Westwater.

On the other hand, a question remains about the instability and uncertainty associated with funding. A significant consequence is that a very talented team of researchers is placed in a position in which a substantial portion of their time and effort is devoted to administrative and fund-raising efforts, rather than to the actual conduct of research. In the long-term, the consequences of this type of situation could be substantial and serious.

Chapter 3

ISSUES AND CONCERNS PERCEIVED TO INFLUENCE RESEARCH EFFORT

3.1 INTRODUCTION

The intent of this chapter is to focus on the subjective response information obtained during the study. The current arrangements and level of effort were presented in Chapter 2, whereas the focus of this chapter is primarily to summarize the perceptions of pertinent aspects of water resources research as currently being carried out in Canada.

3.2 SUMMARY RESPONSES DERIVED FROM THE QUESTIONNAIRES

The most interesting findings related to the subjective aspects of the questionnaire are described below.

3.2.1 Continuing Education Issue

Concerns with the need for continuing education were those mentioned most frequently in the questionnaire responses. Historically, one successful means by which professionals updated their knowledge was through the hiring of new employees. The transfer of technology then occurred by the working association. However, the opportunities for hiring, apparently,in all sectors of employment (government, private and university) appear limited with the likelihood that this mechanism for continuing education opportunities is becoming very limited.

At the same time, opportunities for attending conferences and continuing-education short courses have been extensively curtailed because of budget limitations. Some professionals are attending at their own expense but obviously this is not an option available, nor supported by all. The awareness of "who is doing what" and "who to contact to find out the latest specifics on research" is thus being seriously curtailed.

Some programmes exist for upgrading of technicians but such opportunities for professionals are very limited. Individual professionals are generally not in a position for retraining themselves by, for example, taking time off without pay. The concern with obsolescence and need for continuing education was extremely widespread.

Unless the results of research reach users quickly, in a readily usable form, their value is limited. Further, unless research results are known to other researchers as soon as possible, unnecessary duplication of effort is possible. Thus, transfer of technology problems and communications must be addressed.

Several possibilities exist to overcome aspects of the problems with continuing education but none are likely to succeed unless some initiatives currently not in place, are enacted. The initiatives include:

(a) to have sabbatical opportunities provided for industrial and governmental people. These sabbaticals may involve one of a series of

initiatives including individuals receiving term or year-long appointments to universities.

(b) to have increased offerings of short courses. Because of Canada's limited population and high travel cost, one scenario suggested was to use the EPA model where the short course instructors offer the course in a series of locations. The fees in these courses are minimal, with the fees and transportation/living costs of the instructors being underwritten by EPA.

(c) it is not apparent that universities are currently well organized to give "re-treading", but this should be changed.

3.2.2 Changes to Improve the Capacity of Federal Programs to Respond to Changing Priorities

The question related to the changes that should be made to improve the capacity of federal research programs to respond to changing priorities elicited considerable response.

Federal employee responses encompassed the range from difficulties associated with "inhouse" organizational problems, to how inhouse research programs might be enhanced by improved communication with professionals outside the government.

Specifically:

(a) "the growth of bureaucratic demands on scientist time should be limited" and "recognize research as a legitimate government activity and not something to which only lip service is given" are two representative comments made by federal research scientists that express strong, but fairly widely-held opinions;

(b) resource allocations have been made simply on 'regional parity', rather than on proven competence and performance excellence. This response expresses one element of the important trade-off between centralization and regionalization of federal resources.

(c) there should be an improvement in the use of post-doctoral fellows as a means of increasing numbers of professional staff to carry out the research. Reduced resources available to federal groups have almost eliminated use of post-doctoral fellows.

(d) a large portion of research should be 'market-driven'. Secondment arrangements with industry and universities should bring a team of professionals together to address a specific priority for a specific term.

All of these comments would appear to have merit for making changes to the existing system.

3.2.3 Changes to Improve Coordination of Federal Programs

This question also elicited widespread response, with differences in opinions expressed in response to category of employment. From the federal sector, the comments included:

(a) A coordinating mechanism among federal departments should be established, not to direct research but to provide guidance and leadership. University representatives were suggested as potentially being involved.

(b) There is inflexibility in resource allocations within the federal sector. There is overlap and, even worse, partially complete research efforts because departments are unwilling to transfer money or manpower to research programs outside their control. This criticism relates back to an oft-expressed concern that promotion in the federal sector is related to the pyramidal structure of people beneath them - if money is transferred out or remains unspent, then changes may be made to restructure a group's organization.

(c) another comment that is distressing in some respects is "don't expect private consultants to do research from federal funding. Let them do the short-term applied work for which they are organized". This comment shows a strong bias on the part of federal reserchers, and to some extent, a shortcoming of the structure of the organizations of private consultants. This funding allocation is certainly dramatically different from the U.S. approach which has extensive research being done in the private sector - the question then arises "whether the consultants' structure is the result of the funding" or "is the lack of funding provided creating a structure capable of doing only short-term applied work" (if the latter structure actually is the situation).

With a large organization, it is difficult to identify changes that should be made but, regardless, frequent comments were made that argued for enhanced flexibility at a minimum.

Consultants' comments on this issue include:

(a) an 'on-line' record of ongoing research activities cross-referenced by agency, topic, principal researchers, disciplines, funding source, etc. should be established. This comment relates to enhanced needs for communication.

(b) there is a need for a national institute to develop long-range viewpoints. Presumably, this function should be provided by the existing NWRI and NHRI but, at least to some extent, this role is not functioning.

(c) some obvious dissatisfaction with decision-makers within the federal sector (presumably those associated with deciding the recipients of research funding). The comments included "decision-makers are normally out of touch with reality" and "fire the dinosaurs". Whether these opinions are valid is unknown but the simple fact that the comments were made shows dissatisfaction that warrants some consideration by the federal sector.

Consultants and university personnel comments included: "Stop changing people's jobs every two years into new positions they know nothing about". The "all-too-frequent" response of federal researchers is that since they have only been in their position for x months, they don't know what is going on.

3.2.4 Time Durations Before Appearance of Research Results

A major difficulty with existing research is the time required before improvements are derived. The considerable time-lag occurs because the following occurs:

(i) an individual recognizes a need;
(ii) research work is done;
(iii) the results are published;
(iv) with appropriate findings, the media publicize the work;
(v) political pressure is developed; and,
(vi) Treasury Board approves financing.

In the cases of toxicology and acid rain, steps (i) through (vi) required ten years. As a follow-up, to actually observe an improvement in the environment, a number of additional years are required. For example, it was another 25 years, for a total of 35 years, before significant improvements in lake eutrophication of Canada's water bodies started to become apparent.

In a quest for reducing the time duration before the appearance of the results of research, it appears that a new approach must be adopted. Current procedures for funding tend to promote research by committee. Psychologists have found that only one member of a committee needs to speak strongly to "sink" a proposal; thus, "arrogant upstarts" suggesting radical ideas tend to be suppressed and yet it may be a radical idea that will provide a significant breakthrough.

An approach to possibly preventing the difficulties discussed above is to create a new set of managers. This set of managers of research would have a specific budget set aside to fund research that has a risk of "not going anywhere". With the current system, managers are afraid of being wrong and tend to practice "safe" science. The opportunity of a "super" group with risk capital entails a potential mechanism for discovering breakthroughs while accepting the knowledge that some failures will occur. Such a "portfolio" approach may provide opportunities to decrease the duration for research results to be developed.

3.2.5 Duplication in Government Efforts

Although some duplication in research effort funded by the federal government was acknowledged, the survey responses indicated that such duplication as exists, is beneficial. The consequent checking-of-results and degree of competition that arises from such duplication is favourable.

On the other hand, some strong criticisms have been levelled at the current operational mode viz, "as a result of federal policy on research funding, research on Canada's water resources in general .... has become monopolized by government scientists" (Great Lakes Institute, 1984). As well, research efforts dispersed across Canada, instead of being carried out in a few centres, increases the awareness of local issues and benefits local economies -- although there are numerous detractions from decentralization policies.

3.2.6 Need for Inter-Group Research Efforts

In many cases the scientific investigator's research options are narrowly defined in accordance with departmental mandates and current bureaucratic organizational frameworks. In such circumstances it is unreasonable to expect environmental scientists to be very effective at producing meaningful information issues that are interagency, interdepartmental, interprovincial and international.

Competition between water uses is not only growing but the potential for more serious conflict between uses is inevitable. These concerns must be reflected in future research funding policies, to reflect the need for greater inter-group research efforts.

3.2.7 Age-Distribution of Researchers

Government policies to curtail in-house research have meant that few new professionals have been hired over the past decade, into government research groups. The average age of professionals in the public service has consequently increased during this time with the average age now being approximately 47. New professionals are not being added to the public service in sufficient numbers for the research institutions to benefit from the normal transfer of knowledge from older to younger staff, nor for the older staff to learn of new developments from the younger staff.

In combination with the cutbacks in opportunities for retraining, and attendance at conferences, the result has been an undermining of the feelings of self-worth and mission that the public service had in the 1950's and 1960's. Because of the relatively-young average age of professionals, the concern expressed so frequently in the survey of pending obsolescence is a very great problem which, without a change to the existing structure, will be a problem for many years into the future.

It should be noted that in the context of aging researchers, programs such as the Canada Works program accomplish little. Although useful for providing resources for "legwork", little contribution to "heavy thinking" occurs.

3.2.8 Termination of Data Collection Efforts

Data collection efforts provide an essential element of research studies. However, data collection programs have the characteristic of continuing in perpetuity. The decision-making system to identify when data collection efforts should be terminated, is not generally

available. If, for example, a saving of 100 person-years were to be created by the introduction of a new piece of data collection equipment or the identification that the collection efforts should be terminated, the loss of the person-years would probably create a down-grading of a boss's job. A considerable resistance to such changes thus develops.

3.2.9 The State of Canadian Journals Dealing with Water Resources

In response to the question asking whether Canadian researchers are happy with Canadian journals, the response was "yes", which is a good testimonial to the sophistication and quality of the existing journals. It appears that individual researchers are not likely to increase their publishing significantly in Canadian journals since there is a limited audience, and particularly, little recognition at an international level arises from technical papers published in these journals. As well, most papers are published where the author(s) feel most of the targeted readership lies. The result is that a continuation of the existing effort in Canadian journals is appropriate to upgrade and improve but no expectation of large changes in operational mode should be expected.

3.2.10 Priorization of Major Constraints on Research Productivity

Of interest was an identification of the major constraints on researcher's productivity - shortage of funds, time, shortage of personnel, shortage of technicians, inadequate space, inadequate equipment, other (?).

Rankings as indicated by university researchers, by no means unanimous, were (a) funding, (b) time and technical personnel, and (c) space and lab equipment. Additional comments received that indicate important concerns include:

(a) "significantly large amounts of funds need to be committed for three to five years at a time to allow one to offer satisfactory employment to competent research associates". A related response frequently made was "many students and funds are available but the need is for people (with experience) to supervise the day-to-day work".

(b) "freer access to the equipment and facilities at government labs would greatly aid university researchers". This opportunity would appear to be a valid consideration to be explored.

(c) increased funding would allow solving any of the above-mentioned problems. However, some responses were very strongly worded including "all of the above are priorities. We are starving - if we were mildly undernourished, priorities might be established". This type of comment typifies the very emphatic attitudes of numerous university researchers.

Ranking by government researchers were (a) professional personnel, (b) technical personnel, (c) funding, (d) equipment and space.

3.2.11 Proposal Preparations by Researchers

The responses to the question asking how many proposals were written and the major reason why more proposals were not written provided some interesting responses on the state of water resources research in Canada. This question was directed specifically at university professors to better identify existing constraints on research levels and how changes to existing funding levels might change the system. Responses provided an interesting set of insights, including:

- "the bureaucracies of the funding agencies versus the monies they have to award make the exercise hardly worth the effort".

- "the administration of small projects takes excessive effort".

- "problems of time between notification of grant programs and deadline of submissions were not sufficient to prepare properly".

- "I had more work than I could do, without making any more proposals". On a similar note, "I did not submit more proposals because of limits on my time and the absence of support personnel". For active researchers there are apparently many constraints on time that could be alleviated by the addition of professional support personnel who could assume some of the supervisory role of research.

As for numbers of proposals prepared and funded, a great variability was readily apparent from the questionnaire responses. Some researchers reported a very high success rate on proposals submitted - it appears that the individuals who themselve are very good/well-connected to scientific contract officers, prepare good proposals, have high acceptance rates on proposals and very active research programs.

3.2.12 Attitudes Toward "Buy Out" by University Professors

Significant interest is being expressed by some university researchers in the opportunity to "buy out" from some of their teaching tasks. The intent is that research money is used to hire other individuals to assume some (but not all) of the teaching responsibilities. The pros to such an opportunity include freeing some time for the professor to devote greater time to research and the opportunity provided to bring additional personnel into the university environment, albeit for a limited tenure.

The cons to the buy out policy include the potential for abuse by excessive utilization of the buy out procedure and the potential for inappropriately prepared and/or committed individuals to be involved in teaching.

The response to the question posed in the questionnaire resulted in 26 in favour and 12 against the buy out procedure. As a result, there is majority support which indicates that the policy should be considered -- the policy cannot be a success, however, unless changes are made to the existing funding guidelines of most funding agencies.

Professors need to illuminate their teaching with their own reserch experience and the most productive researchers should also have the opportunity to train tomorrow's researchers.

3.3 SOME SUMMARY FINDINGS

The subjective aspects related to water resources research discussed in this chapter are far-ranging and to some extent represent elements of a "wish list". Regardless, the information summarized should be carefully evaluated since there are some important messages contained herein. Some changes would be easily enacted, whereas others would represent major adjustments from current operational modes.

The intent herein is to indicate below some fairly specific changes that should be given very serious consideration:

(i) communications between professionals should be enhanced. Such enhancements may assume many forms but should include: a catalogue indicating sources of funding to improve the awareness of researchers of the existing sources and objectives; secondly, improvements in indicating who is undertaking various types of projects, with contact addresses and phone numbers; improvements in data management and availability should be made;

(ii) a great need exists for programs directed toward the retraining and continuing education of research professionals;

(iii) a water resources research advisory committee should be formed to develop statements of needed research, on a regular basis;

(iv) some "risk" funding to support research that may provide significant breakthroughs should be created. As a part of such a structure, supervisory professionals should not be "hauled upon the carpet" when failures do occur;

(v) as related to university funding of research, additional long-term funding is needed to increase opportunities for full-time researchers. Such individuals could assume some of the supervisory effort of graduate students, could learn from the ongoing research as well as provide employment opportunities not currently available;

(vi) consideration should be given to increasing federal assistance perhaps on a matching grant basis, to increase the research expenditures being made by the private sector.

Chapter 4

PRIORITY AREAS FOR FUTURE RESEARCH

4.1 INTRODUCTION

During the public hearings, the workshop and the review of pertinent material, a broad array of research needs was identified. These needs ranged from general concerns with pollution, flooding and water supply, to very specific concerns such as farm-related contaminants into water bodies, peatland water resources, river ice processes, estuary hydrodynamics to freshwater in the boreal plains. In this chapter the focus is upon those water research needs which are of national significance and therefore of concern to the federal government.

4.2 PRIORITY RESEARCH NEEDS

On a regional basis, Atlantic Canada appears to have been least well served regarding water resources research by the federal government. No national research institutes, nor affiliated branches, are located in Atlantic Canada. In contrast, other regions of the country have at least a branch of a national research institute located in their area. Thus in substantive terms, Atlantic Canada should receive at least a regional research office. British Columbia now has a branch of the NWRI. It has been reported that the branch will be transferred to Saskatoon when the new building for the NWRI is completed. If that occurs, British Columbia will be without a regional research centre and may find that some of its regional needs are not satisfied.

Regarding major water-related problems, a number of issues remain. While inventory and monitoring programs exist, there still is not an adequate understanding of the basic nature of the water resources. Initiatives in this area often will have to be pursued in cooperation with the provinces, but the goal should be to steadily expand and upgrade inventory and monitoring networks so that the quantitative and qualitative aspects of the water resource are more clearly defined.

In addition to improving our descriptive knowledge of water, effort is needed to improve our functional knowledge, especially with regard to the following topics. Groundwater deserves much more attention. In addition to improving technical knowledge of groundwater resources, there is a need to clarify the legal and economic considerations related to groundwater.

Water diversions or transfers also deserve attention. While public attention often focusses upon the possible impacts of international transfers, many transfers already have been implemented within Canada. Quinn (1981, 68) identified approximately 60 water transfers scattered across nine provinces, the majority developed for hydropower generation, with irrigation, flood control and municipal uses assuming some importance at a regional scale. That number provides a substantial base of experience from which to analyze the environmental, economic and social impacts of transfers. Improved understanding of those

experiences should be invaluable as the possible impacts of transfers in the future are considered.

Water quality attracted the most water resources research effort in the 1970's and early 1980's, and will continue to be a major issue in the future. Increasingly-sophisticated monitoring equipment is allowing identification and measurement of pollutants which in earlier decades could not be traced. The continued monitoring of these pollutants, especially in interjurisdictional water bodies, will continue to require vigorous federal reserch effort. Disposal of toxic wastes represents a particular problem with extensive implications for water quality, given the possibility of leakage and migration of such wastes from underground storage sites. Since leakage or migration of toxic wastes poses a potential threat to water supplies, research focussing upon handling and storage is necessary. Given the serious implications of acid rain for regional economies combined with the international dimension of the issue, the federal government also should continue to maintain an active research program so that Canadian negotiating teams can be supported by the strongest possible evidence.

Environment Canada (1983, 41) estimated that as many as 200 communities across the country have potential flooding problems. The National Flood Damage Reduction Program introduced in 1975 has given a strong incentive toward developing a more balanced approach using both structural and nonstructural adjustments. Given the fairly recent use of nonstructural adjustments, further research is required. Priority areas of research could include the impact of floodplain designation on property values as well as the conflict between realizing flood damage objectives and the preservation of heritage structures located on floodplains. While these types of issues do not have the profile or visibility of international water transfers or acid rain, they are more likely to impact directly the day-to-day living of individuals. Thus, federal research activity should attempt to achieve a balance among these various types of issues.

Many submissions to the Inquiry called for more attention to demand management. As this is still a new concept and therefore either not understood or else misunderstood by many people, the federal government, in cooperation with others, should take a lead role through its research program to identify and clarify options in demand management. This area also is an excellent candidate for the development of demonstration programs and projects which would facilitate public understanding of demand management as well as permit systematic assessment of the effectiveness of some of the strategies (Tate, 1981, 164-166; Mitchell and Robinson, 1984). As demand management can have implications for residential and industrial water supply, irrigation systems as well as wastewater treatment systems, it should be given high priority in a federal research program. Furthermore, if demand management is to be developed, a parallel effort is required to improved demand forecasting models.

In the submissions to the Inquiry, it often was argued that many water problems such as non-point source pollution have their basic causes in associated resource systems. Consequently, there is a real need to strengthen research efforts which cut across resource sectors

and also cut across the mandates of various federal government departments. One of the motives behind the creation of Environment Canada was to place responsibility for renewable resources within one agency. While that was done, there is evidence that the various directorates or services often "go their separate ways" in the conception and implementation of research activity. If some of the more complex and enduring water problems are to be resolved, more research activity must be designed to draw upon the skills of investigators in a variety of agencies. Simultaneously, granting organizations should alter their procedures to better accommodate applications for interdisciplinary, policy-oriented studies based in universities and the private sector.

4.3 MAJOR THEMATIC NEEDS

In Section 4.2 needs were discussed with reference to different substantive water issues. In this section, research needs of a more general, or thematic, nature are identified.

4.3.1 Efficiency of Water Use

Although Canadians are extremely fortunate in the water resources generally available, there are both regions of shortages and considerable potential economies which could be realized through increased efficiency of water use. Research is needed to identify more effective ways of using water for a variety of purposes including domestic, industrial, agricultural and hydro electric use. This concern with efficiency should also lead to much more attention in research to analyzing alternative demand management strategies, as was discussed in section 4.2.

4.3.2 Estimating Impacts of Water Development

An improved capability is required to quantify the impacts from water-related development. Work is especially needed with respect to both ecological and social impacts which cannot always be measured in dollar terms.

4.3.3 Incorporating Risk and Uncertainty

Better procedures are needed to accommodate the presence of risk and uncertainty in water management and development. In water resources development the unavoidable existence of a probability of failure requires improved methodologies to reflect the trade-offs between benefits, costs and risk elements.

4.3.4 Conflict Resolution

Since there are many, and often conflicting, legitimate values and interests associated with water management and development, research concepts and methods which could contribute to resolution of conflicts would be very valuable. Over the last decade there has been an emergence of research focussed on conflict resolution but involving a variety of approaches (gaming, bargaining, and environmental mediation). There is a need for work which integrates these different approaches and

contributes to the drawing together of both qualitative and quantitative information.

4.3.5 Integration of Engineering, Natural Sciences and Social Sciences Analyses

Another type of research needing support is work integrating engineering, natural science and social science research. Existing funding organizations do not easily handle research proposals which cut across disciplinary or professional boundaries. A systematic review of policies and procedures used by the major funding agencies to deal with interdisciplinary research is needed, as researchers have expressed considerable frustration and disappointment with current arrangements.

4.4 AN ADDITIONAL CONSIDERATION ABOUT RESEARCH NEEDS

It should be emphasized that there are literally thousands of legitimate water research projects which can be identified and justified. However, in this chapter, attention has been directed to research needs of a more strategic nature. From each one of the strategic areas, a host of individual research projects could be developed. The criteria for selecting priority research needs here has related to issues deemed to be of national significance, pertinent to the federal government.

For those interested in a detailed inventory of possible research topics, both by water sector and by region, the report by LeFeuvre (1984) provides an extended and detailed list.

Chapter 5

A STRATEGY FOR WATER RESOURCES RESEARCH

5.1 INTRODUCTION

Having reviewed research trends and patterns, and examined issues and concerns, it is appropriate to consider what might be the components of a strategy for water resources research in Canada. Several general observations are necessary. First, while a primary purpose is to indicate the federal role in water research, that task cannot be approached in isolation from the potential role of other groups and interests. As a result, an objective here is to define the characteristics of a national strategy, and then to indicate the role of the federal government within such a strategy. Second, it is recognized that any strategy will have to accommodate at least two components: the substance of research and the process of research. Third, it is appreciated that a number of alternative strategies is available. Each has strengths and weaknesses. None is perfect. As a result, an objective is to identify alternative strategies and their relative merits. And fourth, it is acknowledged that the feasibility of any strategy is related to the funding which is provided. Thus, it is important that attention be given to the level of financial support for water resources research in Canada.

5.2 THE COMPONENTS OF A NATIONAL STRATEGY

If a national strategy for water research and related scientific activity is to be developed, a number of basic functions must be fulfilled. An adequate inventory of water resources regarding both quantity and quality is needed. If trends and patterns are to be identified, systematic monitoring must occur. Inventory and monitoring are needed to provide basic descriptive knowledge of the water resource. Other activity must occur if functional knowledge or understanding is to be realized (Dorcey and Hall, 1981, 7-13; Dorcey, 1984, 2-5).

Functional knowledge can be developed in several ways. Desk analysis involves the examination of existing information with regard to given problems or issues. It also will be used in the assessment of policies, programs and projects and is frequently relied upon in social science research. Experimental research involves the testing of cause-effect relationships, often in laboratory settings. This research usually is associated with the natural, life and engineering sciences. Experimental management may be combined with or follow from desk analysis or experimental research. The purpose is to explore on a constrained scale some of the implications of the functional knowledge which have been developed.

If research is to be supportive of water management, the stage of experimental management should be a key component of any national strategy. However, two other components also are needed. Technology transfer should be an explicit part of a research strategy. In other words, if research is to contribute to resolution of societal problems, resources must be provided to facilitate the development of new ideas to the stage where they can be adopted by potential users. Another

important component is education and training. Research not only should contribute innovative ideas and products but also should serve as a vehicle to educate future investigators as well as to help current researchers improve their skills and talents.

Thus a national strategy for water resurces research and related scientific activity should have the following seven components:

(1) inventory
(2) monitoring
(3) desk analysis
(4) experimental research (laboratory and field)
(5) experimental management
(6) technology transfer
(7) education and training

5.3 CRITERIA FOR ASSESSING ALTERNATIVE APPROACHES

While there is strong support for a significant federal role in water resources research, it is important that any such research effort be managed as effectively as possible. In that regard, explicit criteria help to identify the relative merits of alternative approaches. Five criteria are used here to facilitate a review of alternatives, namely:

(1) coordination
(2) efficiency
(3) anticipatory
(4) user-responsiveness
(5) balanced perspectives

Coordination of research effort at a national scale is probably the most important criterion, given the distribution of research effort among and within many organizations. If "care must be taken not to fragment the effort" (Canadian Water Resources Association, 1984, 17), then both research effort and activity across the nation and among various sectors need to be integrated and coordinated. Without such coordination, there never will be an optimized national research effort whose benefits should, and can be, greater than the sum of the individual parts.

Efficiency also is a key concern, even accepting that many of the products or services from research are of an intangible nature and therefore difficult to treat in benefit/cost or other quantitative terms. Nevertheless, even if efficiency of research cannot be always measured directly in quantitative terms, awareness of this criterion can guide a more qualitative review and direct attention to more obvious instances of duplication and overlap.

A national strategy should stimulate anticipatory research. As Ayles (1984, 2) explained this concept, anticipatory research has a mission orientation but not in the sense that it is striving toward solution of a particular problem which is widely apparent. In contrast to that latter type of work, anticipatory research "is directed toward the research of the future. It should be aimed at providing distant early warning systems for the future "dioxin problems" and "acid rain" problems".

A key element of anticipatory research would be encouragement for investigators to tackle the really complex and difficult problems. Too often, the present system provides a disincentive for addressing difficult problems. As Cardy (1984, 2) observed, "where results count, where output is measured and solutions are required, it may appear more rewarding to go after the easier problems rather than those that may remain insoluble". Thus, a system is needed which provides incentives for futures-oriented research which addresses the really difficult problems and may not always be "successful".

Expressed in another way, there is a need to encourage research which is of a high risk nature in the sense of not providing immediate and direct results. As Wright et al (1984, 5) observed in their report dealing with technology development in Canada, encouragement of high risk research is not readily given since "in government, ..., acknowledgement of failure is often postponed as long as possible. ..Public servants and their political masters are, by nature, risk-averse; research and development, by its very nature, is an exercise in the management of risk. It is not a promising combination".

Some tension will occur between anticipatory research and research which is user responsive. User responsiveness requires that a portion of research effort should relate directly to the needs of users, whether these be government line agencies or the private sector. For this to occur, there must be much more interaction between the researchers and the managers or users. In this regard, Dorcey (1984, 1) has argued that the most fundamental question has often been ignored - "how can we design a process for setting research priorities so that they better meet the needs of water resources managers?"

The final criterion outlines the need for balanced perspectives in research. A mechanism is required to ensure that appropriate attention is directed to technical, economic, social and environmental aspects of water issues and problems. In addition, there is a need to ensure that social science research activity is given reasonable weight relative to the natural and engineering sciences (Dorcey, 1984, 8; Spence, 1984, 3). Furthermore, a need exists to facilitate interdisciplinary and policy-oriented studies (Ashton, 1984, 4; Dorcey, 1984, 7; Slivitsky, 1984, 10).

Other criteria might be included, and could lead to emphases upon different approaches to research. However, in this review, the five criteria indicated at the outset of this section will be used.

5.4 ALTERNATIVE APPROACHES: STRENGTHS AND WEAKNESSES

A number of alternative approaches which combine the research components (Section 5.2) and criteria (Section 5.3) are identified here. The components and criteria are not used in a matrix-like fashion to assess the alternatives, but rather as general guidelines to direct the review. It also should be recognized that while the alternatives are discussed one by one, several of them could be combined to make a larger "package".

5.4.1 Status Quo

The existing situation is characterized by a strong federal role in research, both as a "doer" of research by its own agencies and as a "facilitator" of research through contracts and grants to others (universities, and the private sector). A basic inventory and monitoring program is in place, and a range of desk analyses, experimental research and experimental management occurs. Education and training is supported through block grants to the provinces for post-secondary education, and by research grants and scholarships to faculty and students. However, upgrading and re-training of scientists within the federal system is not easily handled. Technology transfer is in a stage of infancy, with only a few well supported demonstration and transfer programs (such as the demonstration project for sludge incineration being funded by the Wastewater Technology Centre).

Given the number of participants distributed among many organizations involved in research, a need exists for improved coordination to ensure that effective use is made of the research talent available within the country. No effective mechanism seems to exist to coordinate water resources research at a national level. In the interests of efficiency, laboratories and other research activity have been centralized during the past years. This centralization has generated concern for some that water problems in some regions are neglected. Due to the regulatory mandates of the lead water agency, Environment Canada, much of the research effort is directed by the program needs of line agencies. Relatively little anticipatory research can be done within the federal government, and as the water research funds available to the universities were sharply cut in 1979, anticipatory research is at a modest level there as well. A balanced perspective in research is still being sought. A relatively small social science research effort exists, although there is some fine work occurring at selected places in the country. Proposals for interdisciplinary, policy-oriented work conducted outside of the federal government experience difficulty in obtaining funding due to the structure of funding or granting agencies.

Thus, while water-related research of international calibre occurs in Canada, the current system is not perfect. The alternative approaches discussed below do not imply a discarding of much of what is being done at the moment, but rather indicate some modifications of institutional arrangements as well as suggest changes in some basic values which appear to guide the management of the water management process.

5.4.2 National Water Research Committee

If it is accepted that a national strategy is needed which integrates the talent and effort in the federal and provincial governments, universities, private sector, and interest groups, and if it is also accepted that water management in Canada involves many activities (data collection, research, planning, mediation, regulation, control, development), then the suggestion for a National Water Research Committee is appealing.

Creation of such a Committee would require significant federal initiative since the federal government is the one organization in a position to identify and to deal with the range of possible participants. The establishment of such a Committee would also be an explicit statement by the federal government that federal and national water strategies are not identical, that the provincial governments have an explicit role in shaping a national policy, and that water research should be linked to water management and development questions.

The National Water Research Committee would serve as a mechanism to identify and begin to coordinate research needs in various regions, sectors and professions/disciplines across the country. By bringing together individuals representing a variety of perspectives, it could begin efforts to ensure a balanced perspective in research, to strive for user responsiveness, and to ensure more anticipatory research. It also could identify opportunities for technology transfer as well as education and training.

Such a Committee would only be viable if it were given a mandate and the financial resources to ensure that it had some leverage to influence action. If it were created as only an advisory group, it would run the risk of being ignored by the vested interests which already create some of the stumbling blocks to more effective use of Canadian research talent. Such a Committee should be established with a "sunset" clause to ensure that its effectiveness would be reviewed regularly.

5.4.3 Federal Committee for Water Resources Research

Simultaneously with the creation of a National Water Research Committee, the federal government should establish a group to address the integration of federal water research efforts. At the moment, individual departments, ministries, services or directorates have research committees but no one group is responsible to review the water research effort for the entire federal system. The Interdepartmental Committe on Water does not, and cannot fulfill that role, since it does not meet frequently enough, does not have enough "researchers" among its membership, and too often serves primarily to relay information after decisions have been taken. Thus, whatever form such a federal research group might take, it is considered essential that a mechanism be created which can take an overview of federal water research activity in aggregate. Without a clearer sense of the ongoing nature of the overall federal effort related to water resources research, it will be difficult for the federal government to participate in any forum which might be established to develop a national strategy.

5.4.4 National Research Institutes

In order to realize economies of scale, the concept of centralized national research institutes is attractive. Several of these already have been created - the National Water Research Institute (Burlington), the National Hydrology Research Institute (in Ottawa and scheduled tc move to Saskatoon) and the Freshwater Institute (Winnipeg). These were established to provide coordination among a number of organizations involved in research, efficiencies in provision of sophisticated

laboratory equipment, and interaction among scientists working in close proximity. These three characteristics are all real benefits. At the same time, however, this centralization has led investigators in some regions, especially Atlantic Canada, British Columbia and Alberta, to question the appropriateness of much of the research conducted in these institutes for the problems specific to their regions.

5.4.5 Regional Research Centres

To overcome the disadvantages associated with centralized, national research institutes, the alternative of regional research centres exists. This alternative could be developed in several ways. One would be to have a number of regional centres distributed across the country, each one focussing upon the issues and problems of its region. This option would ensure that regional needs were satisfied, but would lead to some duplication of effort for problems common to more than a single area. In addition, it would add expense if laboratory facilities were to be duplicated in the regional centres. Thus, the ability to respond to specific regional needs on an ongoing basis through regional centres would incur extra costs.

Another option would be to have smaller scale regional centres linked to national research institutes and/or a national council. In that manner, the research common to several regions could be conducted at the centralized national institutes where the sophisticated testing equipment could be concentrated. At the same time, regional centres would provide the flexibility to respond on a continuous basis to the needs in individual regions. In a modest form, this approach is in use, with, for example branch offices of the National Water Research Institute being located in Winnipeg and Vancouver. However, the small number of researchers and support staff in these branches makes it virtually impossible for them to address the range of problems in their regions. Furthermore, regions such as Atlantic Canada do not have a Branch and therefore are severely constrained.

Some of these regional centres could be designed to incorporate other related resource problems. For example, many erosion and water pollution problems have their root causes on the adjacent land resources. The regional centres thus could address water problems in relationship to associated land-based resources, or build explicit links with other existing regional research centres, such as those operated by Agriculture Canada. In that context, the following recommendation from the Standing Senate Committee in Agriculture, Fisheries and Forestry (1984, 13) deserves serious attention:

> "That the Federal Government establish Soil and Water Conservation Institutes in Western, Central and Eastern Canada for the purpose of carrying out applied research."

In this regard, it is interesting to note that the Standing Senate Committee (1984, 14) urged a link between regional research activity and a national perspective, and recommended the formation of a "Council on Soil and Water Conservation" which would encourage improved coordination

and cooperation, aid in the priorization of research and program demands, and gather and disseminate information on conservation.

5.5 LEVEL OF SUPPORT

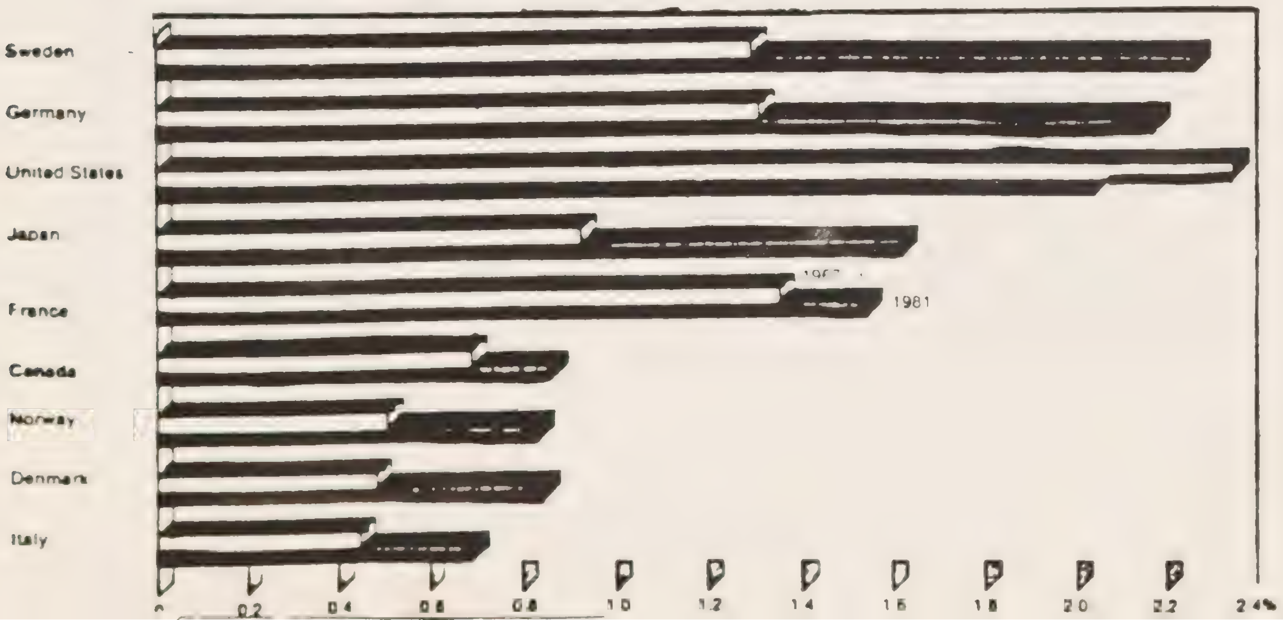
Determining the appropriate level of support for water resources research and related scientific activity is difficult since much of the output is not directly measurable in monetary terms. That problem being recognized, several general indicators can be examined. First, the general commitment to research in Canada can be reviewed by comparing Canadian investment in research and development against other countries. Second, at the federal level, it is possible to identify where research effort is concentrated. And third, it is possible to consider the investment made in water research in Canada and other countries.

One measure of commitment to research and development is the ratio of gross expenditures on research and development and gross domestic product. Using this indicator, Wright et al (1984, 3) concluded that "Canada ranks low on the scale of industrialized countries - far behind the U.S., Japan, Germany, and Sweden". They found that "in recent years, our R&D expenditures have fluctuated between .95 percent and 1.24 percent of GNP. The range in the countries mentioned above, is between two and three percent".

This modest rate of funding for research and development is further confirmed by Figure 5.1 in which Canada is in the middle rank of OECD member countries. However, what Figure 5.1 does not reveal is that most countries, particularly Sweden, Germany and Japan, have increased their research effort during the past 15 years while the Canadian effort has increased relatively little (Statistics Canada, 1984, 20).

Two conclusions may be drawn here. Compared to other industrialized countries, Canada provides relatively modest support for research and development. Furthermore, while other countries have been increasing their overall level of support, Canada has continued to maintain a much more modest level of support. In fields such as water,

Figure 5.1 Industrial R&D as a Percent of Domestic Product of Industry, Selected OECD Countries, 1967 and 1981



this situation makes it difficult for Canadian research on such topics as acid rain to be viewed as credible, since it can be pointed out that Canadian inventory and monitoring networks are inadequate.

Within the federal government, Table 5.1 reveals that the Department of Agriculture and the National Research Council are the main organizations in research and development, accounting for more than 40 percent of the $1 billion total (Statistics Canada, 1983, 23). From the 1984-1985 federal estimates in which it was identified that the Department of Agriculture allocated $2.5 million to water research, it can be seen that water receives about 1 percent of that organization's research funds.

Table 5.2 shows by 1981 that almost half of the research and development conducted by the federal government was performed in the National Capital Region, and that over two-thirds of research and development expenditures occur in the central provinces of Ontario and Quebec. While these figures are for all federal research and development activity, they tend to confirm the earlier observation that there has been a trend towards centralization of research effort.

Provincial research and development expenditures are primarily accounted for by provincial agencies and provincial research councils or foundations. Except for Newfoundland and Prince Edward Island, each province has a research council or foundation. Table 5.3 presents estimates of regional expenditures during 1981. Just under 40 percent of the provincial expenditures occurred in Ontario, and about 60 percent occurs in Ontario and Quebec. With the notable exception of Alberta, Table 5.3 reinforces an overall pattern of research and development activity concentrated in central Canada.

Regarding levels of support for water resources research in Canada, Lefeuvre (1984, 5) indicated that total funding increased to $52 million in 1979 from $20 million (1979 dollars) in 1966. This increase in 250 percent from 1966 to 1979 fell far short of the recommendations by Bruce and Maasland (1968) who called for an increase of 20% per year.

By 1983, the overall funding for water research in Canada was about $56 million; when this is compared with the $75 million (1983 dollars) expenditure on research in 1979, these results show a 25 percent reduction from 1979 levels.

Comparisons with other nations' support for water resources research would place Canadian figures in context. Unfortunately, most of the countries which were contacted with a request for such information could not provide the desired data. In many cases, the negative response reflected the absence of any organization with a mandate to take a national overview of water resources research. Nevertheless, some data are available.

Table 5.1 Expenditures on R&D Performed Within the Federal Government, by Department

Department	1976	1977	1978	1979	1980	1981	1982p	1983p
	millions of dollars							
Agriculture	107	115	126	143	153	178	199	228
Atomic Energy of Canada Ltd.	60	57	68	64	69	82	96	106
Energy, Mines & Resources	48	55	66	64	82	107	132	135
Environment	106	106	60	60	77	84	102	100
Fisheries and Oceans	---	---	67	67	75	85	92	97
National Defence	54	62	61	59	72	78	88	104
National Research Council	81	89	102	112	129	152	191	208
Other	53	72	86	77	80	99	116	117
Total	509	556	636	646	737	865	1,016	1,095

Source: Statistics Canada (1983, 23)

p = predicted

Note - while it appears that beginning in 1978 Environment experienced a decrease in expenditures on R&D, that pattern reflects the splitting away of Fisheries and Oceans from Environment.

Table 5.2 Federal Performance of R&D, by Region, 1981

Province and Region	Millions of Dollars	Percent of Total
British Columbia	45	5
Alberta	46	5
Saskatchewan	24	3
Manitoba	65	7
Western Provinces -	180	21
Ontario	121	14
National Capital Region	417	48
Quebec	64	7
Central Provinces -	602	70
New Brunswick	21	2
Nova Scotia	44	5
Prince Edward Island	5	1
Newfoundland	13	1
Atlantic Provinces -	83	10

Source: Statistic Canada (1983, 23)

Table 5.3 Sources of Funds for R&D Performed Within the Provincial Government Sector, 1981

	Source of Funds (millions of dollars)			
Province	Governments	Business Enterprise	Foreign	Total
Atlantic Provinces	3	1	---	4
Quebec	26	2	---	28
Ontario	46	5	1	52
Manitoba & Saskatchewan	7	1	---	8
Alberta	30	1	---	31
British Columbia	13	1	---	14
Canada	124	11	1	137

Source: Statistics Canada (1983, 24)

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The Australian Water Resources Council (1982, 82) assembled some data regarding expenditure in selected countries on water research as a percentage of the annual capital expenditure on water developments. The results were:

Australia	1.4%
United Kingdom	2.2%
Canada	2.8%
South Africa	2.8%
United States	4.0%

As with indicators for research in general, Canada falls in the "middle ground" regarding its support for water resources research.

The available evidence indicates that Canada has taken a "middle of the road" position in supporting research in general, and water research in particular. Of concern, however, are the reductions in research support to Environment Canada over a period in which the support for research in other federal departments has grown. Those reductions are illustrated by the decrease by three-quarters of the funds in the IWD Water Resources Research Support Program.

The Australian Water Resources Council (1982, 7) recommended the establishment of a "National Water Research Council" to provide advice to the government regarding "national research goals, needs and priorities and the development and management of a comprehensive national water research and technology transfer program". In contrast, in September of 1983 the British government dissolved its National Water Council and in September 1981 President Reagan signed on Executive Order which terminated the American Water Resources Council. Both of these organizations were perceived as not directly accountable or responsible for their actions, which made them dispensible. At the same time, these executive decisions also removed the organizations which had an overview of the national water scenes in their respective countries.

The Australian Water Resources Council (1982, 82) assembled some data regarding expenditure in selected countries on water research as a percentage of the annual capital expenditure on water developments. The results were:

Australia	1.4%
United Kingdom	2.2%
Canada	2.8%
South Africa	2.8%
United States	4.0%

As with indicators for research in general, Canada falls in the "middle ground" regarding its support for water resources research.

The available evidence indicates that Canada has taken a "middle of the road" position in supporting research in general, and water research in particular. Of concern, however, are the reductions in research support to Environment Canada over a period in which the support for research in other federal departments has grown. Those reductions are illustrated by the decrease by three-quarters of the funds in the IWD Water Resources Research Support Program.

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Chapter 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

The previous chapters have described the nature and extent of effort in water resources research in Canada, have identified substantive and managerial issues, problems and opportunities, and have considered the financial implications of present and future research efforts. In this chapter, the major conclusions and recommendations are presented. They all emerge from the findings presented in Chapters 1.0 through 5.0.

6.2 A FEDERAL ROLE IN WATER RESOURCES RESEARCH

Strong support exists in the country for a continued role by the Federal Government in water resources research, particularly regarding problems of an inter-jurisdictional nature. A federal role is not identical with a national water research strategy. Therefore, if the diverse research talent in the country is to be effectively mobilized, a national research strategy must be identified. For the Federal Government to participate in a national strategy, it is imperative that it clearly define its role.

6.3 THE EXTEND AND NATURE OF THE FEDERAL ROLE

The current federal role in water resources research is extremely large. The Federal Government, through its various agencies, presently provides 73 percent of the funds for water research in the country. Furthermore, Federal Government agencies spend 51 percent of the water resources research dollars. These figures demonstrate that Federal Government agencies collectively comprise the main participant in water research both as a 'doer'and as a 'facilitator'.

RECOMMENDATION 1:

THE FEDERAL GOVERNMENT SHOULD CONTINUE TO BE A MAJOR PARTICIPANT IN WATER RESOURCES RESEARCH IN CANADA. HOWEVER, TO MORE EFFECTIVELY USE THE RESEARCH TALENT IN THE COUNTRY THERE SHOULD BE AN INCREASING ROLE FOR RESEARCHERS BASED IN THE UNIVERSITY AND PRIVATE SECTOR (SEE RECOMMENDATIONS 8 AND 9).

6.4 MAJOR MANAGEMENT NEEDS

6.4.1 Coordination

Given the diverse array of research activity at the federal, provincial, private sector and university levels, a very important need is to achieve a systematic coordination of the research effort and to relate research to management needs. The most appropriate approach to develop a national strategy would be to create a National Water Research Committee. Comprised of representatives from the different groups involved in research, it would strive to minimize duplication of facilities and effort across the country, ensure a balance was realized between national and regional research problems, facilitate

communication within the research community and encourage liaison between researchers and managers. The committee would have to be allocated sufficient funds and authority so that it could influence research activity. Without sufficient resources, a great weakness of such a committee is that it could be ignored by the existing line agencies. The Research Committee would be created with a "sunset" clause to ensure that its effectiveness is assessed on a regular basis. This Research Committee could become the first step toward a more, all encompassing, Council which would be responsible for research, planning, management, and development.

<u>RECOMMENDATION 2</u>:

> THE FEDERAL GOVERNMENT SHOULD TAKE THE LEAD IN ESTABLISHING THE NATIONAL WATER RESEARCH COMMITTEE, WHOSE OVERRIDING GOAL SHOULD BE TO DEVELOP A <u>NATIONAL</u> STRATEGY FOR WATER RESOURCES RESEARCH. THE IWD SHOULD PROVIDE THE SECRETARIAT FOR THE COMMITTEE WHICH WOULD HAVE A MAXIMUM MEMBERSHIP OF FIFTEEN INDIVIDUALS (SIX FEDERAL, THREE PROVINCIAL, THREE UNIVERSITY AND THREE PRIVATE SECTOR).

<u>RECOMMENDATION 3</u>:

> THE FEDERAL GOVERNMENT SHOULD ESTABLISH A FEDERAL COMMITTEE FOR WATER RESOURCES RESEARCH WHOSE PRIMARY GOAL SHOULD BE TO DEVELOP A <u>FEDERAL</u> STRATEGY. THE COMMITTEE MEMBERSHIP SHOULD INCORPORATE RESEARCHERS AND MANAGERS FROM FEDERAL AGENCIES WITH A SIGNIFICANT ROLE IN WATER RESEARCH. THE MEMBERSHIP SHOULD REPRESENT BOTH HEADQUARTERS AND REGIONAL CONCERNS.

6.4.2 <u>Efficiency</u>

In the interests of efficiency there has been a trend towards centralization of research effort. There have been at least two major benefits from centralization. First, scale economies have been realized in purchases and operations of sophisticated and expensive laboratory equipment. Second, having large groups of scientists in proximity to each other has provided the critical mass of energy and talent so often necessary for scientific breakthroughs. For these two reasons the centralization trend can be supported.

At the same time, further potential advantages from centralization exist. While on paper it appears feasible for investigators from universities and the private sector to use the sophisticated equipment in government laboratories, in practise such cooperative use has occurred only rarely. Thus, there seems to be considerable opportunity to make some of the sophisticated testing equipment in the federal laboratories available to the larger research community.

On the other hand, there have been major costs associated with centralization. For those regions which do not have one of the centralized research facilities, there is a real danger that their regional needs get overlooked or ignored. To overcome this weakness it would be appropriate to have more regional branches or centers affiliated with the national research centers distributed across the country. At the moment there are several such regional operations. If more regional centers were to be established, the first priority

should be to create such a center in the Atlantic Region. Atlantic Canada seems to be have been inadequately served by national research efforts. British Columbia should be the next priority area concerning a regional centre.

RECOMMENDATION 4:

THE EXISTING NATIONAL RESEARCH INSTITUTES SHOULD BE CONTINUED BUT GREATER PROVISION SHOULD BE DEVELOPED FOR ACCESS TO THEIR SOPHISTICATED EQUIPMENT BY OUTSIDE USERS.

RECOMMENDATION 5:

TO ENSURE THAT REGIONAL RESEARCH NEEDS ARE ADDRESSED, MORE REGIONAL RESEARCH CENTRES SHOULD BE ESTABLISHED. ATLANTIC CANADA SHOULD BE THE FIRST PRIORITY TO RECEIVE A RESEARCH CENTRE.

6.4.3 Anticipatory Research

Funding sources of the Federal Government have increasingly shifted to more mission-oriented research effort. Thus, directions of research have been increasingly influenced by the funding source. Such an approach seems reasonable in times of restraint but freedom and innovation in research may suffer if it is too fully directed. As well, with the current system there is a tendency to fund 'safe' science, where results are essentially guaranteed. However, major issues related to water resources usually are long term in nature and seldom are resolved in less than twenty-five years from the time that they are first recognized as problems or opportunities. Consequently, research must not be 'packaged' as short term tasks to be distributed across the country.

In response to these problems, some portion of the overall research budget should be targeted at innovative and unrestricted water research. A mechanism to allocate such funds could be the National Water Research Committee with a mandate to include future-oriented, innovative research. The mandate of the Committee should specifically include allowance for failure of some research to produce 'positive' results, since the concern of this Committee would be to stimulate truly innovative research that might provide significant breakthroughs.

RECOMMENDATION 6:

A PROPORTION OF THE RESEARCH BUDGETS OF THE NATIONAL WATER RESEARCH COMMITTEE, THE NATIONAL INSTITUTES AND REGIONAL CENTRES SHOULD BE DESIGNATED TO SUPPORT RESEARCH OF A HIGH RISK AND LONG TERM NATURE.

6.4.4 User Responsiveness

A frequent concern is that managers or users and researchers do not consult with each other regarding research needs and priorities. As a result, many times it has been suggested that a mechanism is needed to facilitate such dialogue. The National Water Research Committee if composed of individuals not just from different levels of government, universities and the private sector but also from both managers and researchers, should be able to improve the responsiveness of the research to the needs of users or managers.

If the membership on the committee also included representatives from different regions in the country, then it also should be possible to ensure that distinctive regional problems get fair consideration.

RECOMMENDATION 7:

TO ENSURE THAT THE WATER RESEARCH ACTIVITY RESPONDS TO THE NEEDS OF WATER MANAGERS AND USERS, THE VARIOUS RESEARCH COMMITTEES, INSTITUTES AND CENTRES SHOULD HAVE A MANAGEMENT COMMITTEE INVOLVING RESEARCHERS, MANAGERS AND USERS.

6.4.5 Balanced Perspectives

There appears to be a major need for research activity that integrates findings and understanding generated from research in a variety of disciplines and professions. Unfortunately, many researchers report having significant difficulties in obtaining funding for such interdiscplinary research especially from NSERC and SSHRC.

A frequent observation made to the Inquiry was that there is a need for a larger amount of social science research effort in the water field. It should be recognized that social scientists can apply to the Social Sciences and Humanities Research Council of Canada to obtain research funding. To date, a very small number of social scientists working in the water field have regularly received research awards from SSHRC. Furthermore, SSHRC has received very modest increases in its funding programs, so that major new initiatives in water resources research are highly unlikely, if the historical pattern of funding to SSHRC is maintained.

The Federal Government could take the initiative to encourage or stimulate social science research by identifying more problem areas which require analysis by social sciences and by establishing funds designated to support social sciences research.

Engineering, physical and life scientists have generated substantial funding through the Natural Science and Engineering Research Council. All university-based investigators, however, have expressed disappointment at the modest funding provided for water research through the Inland Waters Directorate subvention program. To achieve a variety of perspectives pertinent to water resources problems, the Federal Government could show much more leadership by increasing the research funding to non Federal Government investigators.

RECOMMENDATION 8:

NSERC AND SSHRC SHOULD REVIEW EXISTING PROCEDURES FOR ASSESSING INTERDISCIPLINARY RESEARCH PROPOSALS IN ORDER TO ENSURE A MORE EFFECTIVE REVIEW OF SUCH PROPOSALS.

RECOMMENDATION 9:

TO ENCOURAGE MORE SOCIAL SCIENCE RESEARCH IN THE WATER FIELD, A GREATER LEVEL OF FUNDING SHOULD BE PROVIDED TO SSHRC FROM THE FEDERAL GOVERNMENT.

RECOMMENDATION 10:

THE WATER RESOURCES RESEARCH SUPPORT PROGRAM SHOULD RECEIVE INCREASED FUNDING AND SOME OF THIS INCREASED FUNDING SHOULD BE SET ASIDE TO SUPPORT SOCIAL SCIENCE RESEARCH.

6.5 COMMUNICATION

The Federal Government has developed an extensive data management system to support water research activity. Given the array of potential users, it is not clear how effectively the needs of the researchers across the country have been serviced by these systems. While these systems provide an inventory of current reports and information, they do not provide a systematic listing of ongoing research activity (investigation, topic, level of support, time-frame).

If coordination of research effort is one of the most important priorities for the future, communication of research results from the investigators to the managers and users is also very much in need of improvement. A major problem appears to be that researchers publish in journals which are primarily read by other researchers, rather than managers or users.

Clearly, there is need for outlets for research whose main target is other researchers. In addition, it is not desirable to have a proliferation of journals and periodicals. However, some of the existing journals, such as the Canadian Water Resources Journal or the Water Pollution Research Journal of Canada, might be encouraged to develop two major sections. One section could contain research reports oriented primarily towards other researchers. The other section might contain articles focussed more towards the needs of users and managers. If this were to be done, the journals would incur extra publication costs. Therefore, in the interests of furthering communication between researchers and managers, the Federal Government might provide some funding to allow this modification.

RECOMMENDATION 11:

GIVEN THE DEVELOPMENT OF THE DIFFERENT DATA MANAGEMENT SYSTEMS, IT IS RECOMMENDED THAT A SYSTEMATIC REVIEW OF THESE SYSTEMS BE CONDUCTED BY THE FEDERAL GOVERNEMENT TO DETERMINE THEIR EFFECTIVENESS AND EFFICIENCY.

RECOMMENDATION 12:

THE FEDERAL GOVERNMENT SHOULD DEVELOP AN INVENTORY OF ONGOING WATER RESOURCES RESEARCH PROJECTS WHICH WOULD BE ACCESSIBLE ON AN ON-LINE BASIS TO RESEARCHERS IN THE FEDERAL, PROVINCIAL, UNIVERSITY AND PRIVATE SECTORS.

RECOMMENDATION 13:

TO FOSTER COMMUNICATION BETWEEN RESEARCHERS AND MANAGERS, THE FEDERAL GOVERNMENT SHOULD PROVIDE FUNDING TO SELECTED CANADIAN JOURNALS IN THE WATER FIELD TO ASSIST THEM IN INCLUDING MORE REPORTS PERTINENT TO THE NEEDS OF MANAGERS AND USERS.

6.6 RETRAINING AND EDUCATION

One of the characteristics of innovative and outstanding researchers is the ability to keep abreast of the most recent concepts, methods and techniques. Traditionally, much of this upgrading and re-education has occurred through the interaction between recently-hired junior investigators and their more senior experienced colleagues, or through people exchanging views and experiences at professional meetings. In times of restraint, when very few new scientists are being hired and when substantial restrictions are placed on travel to conferences, these traditional mechanisms do not work. This must be recognized. If the Federal Government is serious about supporting retraining and education, then sufficient resources must be allocated to either hire new staff, facilitate participation in professional meetings or accommodate sabbaticals or other forms of exchanges by federal scientists with their counterparts in other institutions.

RECOMMENDATION 14:

THE FEDERAL GOVERNMENT SHOULD DEVELOP A SYSTEM OF SABBATICALS AND SHORT-TERM LEAVES TO ENCOURAGE FEDERAL RESEARCH SCIENTISTS TO BROADEN THEIR EXPERIENCES AND EXPOSE THEM TO THINKING AND PROCESSES IN NON-FEDERAL INSTITUTIONS.

RECOMMENDATION 15:

THE FEDERAL GOVERNMENT SHOULD ASSIST THE CONTINUING EDUCATION OF PROFESSIONALS BY PROMOTING OPPORTUNITIES FOR ATTENDANCE AT SHORT COURSES. SERIOUS CONSIDERATION SHOULD BE GIVEN TO ACCOMPLISHING THIS BY FOLLOWING THE EPA EXAMPLE WHERE SPEAKERS AT SHORT COURSES ARE MOVED TO VARIOUS LOCATIONS AND ONLY VERY MODEST FEES ARE CHARGED, SO AS TO ASSIST THE OPPORTUNITY FOR ATTENDANCE.

RECOMMENDATION 16:

THE FEDERAL GOVERNMENT SHOULD EXPLORE OPPORTUNITIES FOR SCHOLARSHIPS TO ASSIST STUDY IN WATER RESOURCES RESEARCH. THE RECENTLY INITIATED PROGRAM BEING USED BY FEARO COULD BE USED AS A MODEL FOR A SIMILAR PROGRAM IN THE WATER FIELD.

6.7 FUTURE FUNDING LEVELS

Funding levels of water resources research in recent years have not kept pace with inflation. Current funding levels represent only 74 percent of 1979 research efforts. This represents a significant decrease in research effort. In the interim, new problems have emerged in the water field.

As a consequence of the decrease in research funding from 1979, an even greater shortfall from the recommendations regarding needs for increased funding as presented in the Bruce and Maasland report in 1968 has occurred.

RECOMMENDATION 17:

GIVEN THE 25 PERCENT REDUCTION IN SUPPORT FOR WATER RESOURCES RESEARCH SINCE 1979, INCREASES IN FUNDING OVER THE NEXT FIVE YEARS ABOVE THE RATE OF INFLATION SHOULD BE INSTITUTED. AN ANNUAL INCREASE OF 10 TO 12 PERCENT COULD BE A TARGET, AT A LEVEL OF 5 PERCENT ABOVE THE RATE OF INFLATION.

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APPENDIX I

QUESTIONNAIRE

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Faculty of Engineering
Department of Civil Engineering
519/885-1211

August 1, 1984

The Science Council of Canada and the Inquiry on Federal Water Policy are the co-sponsors of our study on the status of water resources research in Canada. Attached is a letter confirming this sponsorship. The objectives of the study are:

(1) to provide an updated inventory of water research activities in Canada for 1983 or April 1983-March 1984, whichever is appropriate for your organization, identifying effort in different categories of research and among federal, provincial, university and private sectors,

(2) to identify future research needs and priorities, and,

(3) to evaluate federal research programs in terms of their capacity to respond to changing priorities for water resources research, co-ordination and management in Canada.

Sources being contacted for this information are individuals and organizations across the country involved in water resources research.

We would appreciate your sending us information about the water resources research in your department.

Enclosed are two questionnaires. The Reporting Unit questionnaire is used to collect overall cost and manpower information. The Project questionnaire is used to collect informatio describing individual research projects. These questionnaires should be distributed to the individuals responsible for particular research projects.

We are aware that Bruce and Maasland published a report for the Science Council of Canada on the status of water resources in Canada in 1968, and that in 1979 Environment Canada updated their inventory. Many people across the country took considerable time to provide data essential for these studies. Our assignment in directing this third study involves submission of a report in early 1985, both updating the inventory and identifying future issues, opportunities, constraints and strategies relative to water resources research in Canada. The results of this inquiry will be used by the Inquiry on Federal Water Policy.

Although we are requesting the names of researchers, that information will be used only to facilitate categorizing and processing. Responses will be treated in confidence, and no individual will be identified by name in the report.

For responses from your department to be taken fully into account, we need to receive the completed questionnaire by not later than September 14, 1984. As a result, we hope that you will distribute them as quickly as possible to your researchers, and make them aware of the importance of receiving their input.

If you have any questions, please do not hesitate to contact either of us. For purposes of return correspondence, please direct to:

Professor Edward McBean
Department of Civil Engineering
University of Waterloo
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Yours sincerely,

Bruce Mitchell,
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Yours sincerely,

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THE SCIENCE COUNCIL OF CANADA AND THE INQUIRY ON FEDERAL WATER POLICY

WATER RESEARCH INVESTIGATION

The Science Council of Canada undertook a major study of water resources research in the 1960s which led to publication in 1968 of Special Study No. 5 by Bruce and Maasland, "Water Resources Research in Canada", and Council Report No. 3, "A Major Program of Water Resource Research in Canada." New issues are now emerging (e.g. toxic chemical pollution, interbasin transfers), leading to a need to reassess water research needs between now and the year 2000. Environment Canada convened several workshops a few years ago to examine a number of the relevant issues but did not address the question of where water research should be heading in the future. Science Council has given some consideration to further work in the area.

The Minister of the Environment recently established, with Cabinet approval, a three-member Inquiry on Federal Water Policy, chaired by Dr. Peter Pearse. The Inquiry has the mandate to consult broadly with Canadians and their governments; to substantiate the nature of emerging issues; to assess available supplies and future requirements for the conservation and use of water; and to "assess the needs for, and nature of, additional scientific and research expertise in water management in Canada."

Because of a common interest in future water research activities, the Inquiry and Science Council have agreed to jointly sponsor work in this area and have entered into a contract with Professors Edward McBean and Bruce Mitchell of the University of Waterloo to undertake the project.

The objectives of this joint project are:

1. To update the inventory of water research activities, using the Science Council reports of 1968 and Environment Canada paper of 1979 as bases, identifying changes in effort among research categories and changes in effort and funding among federal, provincial, university and private sectors.

2. To identify future research needs and priorities, in consideration both of current trends and emerging water issues as substantiated by the Inquiry on Federal Policy.

.../2

3. To evaluate federal research programs in terms of their capacity to respond to changing priorities for water resources research, co-ordination and management in Canada.

Science Council of Canada

Don E. Read July 13, 1984

D.E. Read
Science Adviser

Inquiry on Federal Water Policy

Frank Quinn

Frank Quinn
Director of Research

WATER RESOURCES RESEARCH CATEGORIES

100. NATURE OF WATER
Category 100 deals with fundamental research on the water substance.

101. Properties of water — Study of the physical and chemical properties of water, including its thermodynamic behavior in its various states.

102. Aqueous solutions and suspensions — Study of the effects of various solutes on the properties of water; surface interactions, colloidal suspensions.

200. WATER CYCLE
Category 200 covers research on the natural processes involving water. It is an essential supporting effort to applied problems in later categories.

201. General. Including studies involving two or more phases of the water cycle such as hydrologic models; rainfall-runoff relations; surface and ground-water relationships, watershed studies, geomorphology.

202. Precipitation. Including investigation of spatial and temporal variations of precipitation, physiographic effects, time trends, extremes, probable maximum precipitation, structure of storms, quantitative precipitation forecasting.

203. Snow and ice. Including studies of the occurrence and thermodynamics of water in the solid state in nature, spatial variations of snow and frost, formation of ice, break-up of river and lake ice; glaciers, ice forces, permafrost and its effects on groundwater and the water cycle.

204. Evaporation and transpiration. Including investigation of the process of evaporation from lakes, soil, and snow and of the transpiration process in plants, methods of estimating actual evapotranspiration, energy balance.

205. Streamflow. Including mechanics of flow in streams, flood routing, bank storage, space and time variations (includes high and low-flow frequency), droughts, floods.

206. Groundwater. Including study of the mechanics of groundwater movements, multiphase systems, sources of natural recharge; mechanics of flow to wells and drains, subsidence; properties of aquifers, saline water intrusion in coastal aquifers.

207. Water in soils. Including infiltration, movement and storage of water in the zone of aeration, including soil.

208. Lakes. Including hydrologic, hydrochemical, and thermal regimes of lakes, water level fluctuations, currents and waves.

209. Water and plants. Including role of plants in hydrologic cycle; water requirements of plants, interception of precipitation.

210. Erosion and sedimentation. Including studies of the erosion process, prediction of sediment yield, sedimentation in lakes and reservoirs, stream erosion, sediment transport, river-bed evaluation.

211. Chemical processes. Including chemical interactions between water and its natural environment, chemistry of precipitation.

212. Estuarine problems. Including special problems of the estuarine environment; effect of tides on flow and stage, deposition of sediments, sea water intrusion in estuaries.

300. WATER SUPPLY AUGMENTATION AND CONSERVATION
As water use increases we must pay increasing attention to methods for augmenting and conserving available supplies. Research in Category 300 is largely applied research devoted to this problem area.

301. Saline water conversion — Research and development related to methods of desalting sea water and brackish water.

302. Water yield improvement — Increasing streamflow or improving its distribution through land management, water harvesting from impervious areas, phreatophyte control, reservoir evaporation suppression.

303. Use of water of impaired quality — Research on methods of agricultural use of water of high salinity; use of poor quality water in industry; crop tolerance to salinity.

304. Conservation in domestic use — Methods for reducing domestic water needs without impairment of service.

305. Conservation in industry — Reduction in both consumption and diversion requirements for industry.

306. Conservation in agriculture — More efficient irrigation practices. Chemical control of evaporation and transpiration, lower water use plants, optimum use of soil moisture, etc.

307. Weather Modification — artificial stimulation of precipitation; climate modification by changes in land and water surfaces, etc.

400. WATER QUANTITY MANAGEMENT AND CONTROL
Category 400 includes research directed to the management of water, exclusive of conservation, and the effects of related activities on water.

401. Control of water on the land — Effects of land management on runoff, land drainage, potholes, etc.

402. Groundwater management — Artificial recharge; conjunctive operation, relation to irrigation.

403. Effects of man's related activities on water — Impact of urbanization, highways, logging, etc., on water yields and flow rates.

500. WATER QUALITY MANAGEMENT AND PROTECTION
An increasing population increases the wastes and other pollutants entering our water supplies. Category 500 deals with methods of identifying, describing and controlling the pollution.

501. Identification of pollutants — Techniques of identification of physical, chemical and biologic pollutants; rational measures of character and strength of wastes.

502. Sources and fate of pollution — Determination of the sources of pollutants in water; the nature of the pollution from various sources, path of pollutant from source to stream or groundwater; prediction of pollution concentrations including prediction by means of mathematical models, effects of ice cover on dissolved oxygen and other pollutants in streams and lakes, etc.

503. Effects of pollution — Definition of the effect of pollutants, singly and in combination, on man, aquatic life, agriculture and industry under conditions of sustained use, eutrophication; influence of prolonged ice-cover on effects of pollutants, etc.

504. Waste treatment processes — Research to improve conventional treatment methods to gain efficiency or reduce cost, processes to treat new types of waste; advanced treatment methods for more complete removal of pollutants including purification for direct reuse.

505. Ultimate disposal of wastes — Disposal of residual material removed from water and sewage during the treatment process, disposal of waste brines; underground waste disposal.

506. Water treatment — Development of more efficient and economical methods of making water suitable for domestic or industrial use.

507. Water quality control — Research on methods to control stream and reservoir water quality such as flow augmentation, stream and reservoir aeration, control of natural pollution, control of pollution from pesticides and agricultural chemicals, control of acid mine drainage, control of erosion and sedimentation, etc.

600. ECONOMIC, SOCIAL AND INSTITUTIONAL ASPECTS
The problems of achieving an optimal plan of water development are becoming increasingly complex. Category 600 covers research devoted to determining the best way to plan, the appropriate criteria for planning and the nature of the economic, legal and institutional aspects of the planning process.

601. Planning — Application of systems analysis to project planning; treatment of uncertainty; probability studies; non-structural alternatives.

602. Evaluation process — Development of methods, concepts and criteria for evaluating project benefits, discount rate, project life; methods for economic, social and technological projections, reliability of projections, research on the value of water in various uses, etc.

603. Cost allocation, cost sharing, pricing/repayment — Research on methods of calculating repayment and establishing prices for vendible products, techniques of cost allocation, cost sharing; pricing and repayment policy.

604. Water requirements — Research on the water quantity and quality requirements of various uses.

605. Water law — Studies of provincial and federal water law looking to changes and additions which will encourage greater efficiency in water use.

606. Institutional aspects — Investigation of institutional structures and constraints which influence decision on water at all levels of government, case studies, jurisdictional problems.

607. Sociological and psychological aspects — Attitudes to use of water, perception of responsibilities.

608. Ecologic impact of water development — Effects of water management operations on overall ecology, including human ecology, of the area. Excludes effect of pollution under 503.

700. RESOURCES DATA
Planning and management of our water resources require information. Category 700 includes research oriented to data needs and the most efficient methods of meeting these needs. Basic data collection in itself is not here considered research, but studies of ways to improve data collection are included.

701. Network design — Studies of data requirements and of the most effective methods of collecting the data.

702. Data acquisition — Research on new and improved instruments and techniques for collection of water resources data, including data on water use and water and erosion damage, telemetering equipment.

703. Evaluation, processing and publication — Studies of effective methods of processing data, form and nature of published data, maps of data.

800. ENGINEERING WORKS
To implement water development plans requires engineering works. Category 800 describes research on design, materials and construction which is specifically useful to water management. Works relevant to a single specific goal, such as water treatment or desalination, are included elsewhere if an appropriate category exists.

801. Specifications and Design — Studies of functional requirements of water structures, research leading to improved design of dams, canals, pipelines, locks, fishways and other works required for water resource development.

802. Materials — Research to improve existing structural materials and to develop new materials for use in water control and conveyance structures.

803. Operations — Research on efficient operating procedures, and maintenance procedures for water control systems.

900. Environmental Management and Protection

ASSESSMENT OF RESEARCH NEEDS

As with all questionnaires, their distribution must be limited. However, from the responses we must extrapolate the information to characterize the national scene of water resources research in Canada. This is not a task that is simple, nor taken lightly, since there are severe dangers of both omission and duplication. As a result, when completing the questionnaire, please keep in mind:

(i) The scope of research you are reporting for:
e.g. (a) you as an individual ________
(b) the branch, division, or unit in which you work ________
(c) other (specify) ________

(ii) The questionnaire is being completed by an array of people with diverse backgrounds, thereby implying some questions may be more directly relevant to your concerns than are others.

(iii) Please use the reverse side and/or append additional pages as required.

1. In your view, what are the needs and priorities for water resources research in Canada between now and the year 2000? What issues are likely to be most important in the 1990's, and what should we be doing now in research to be ready to address them in the 1990's?

2. What changes should be made to improve the capacity of federal research programs to respond to changing priorities for water resources research? How can/should flexibility be "built in" to the management of research programs to ensure that we address the issues of the future as well as of the present?

3. What changes should be made to improve the coordination of federal programs in water resources research related to various research activities amongst different federal departments as well as in provincial governments, universities, and the private sector?

4. Are results from water research in Canada being effectively applied to the resolution of practical problems? If not, what are the main obstacles to effective application? What should/could be done to improve the use of results from water research in the 1990's to resolve practical problems?

5. In the planning and conduct of water resources research, what proportion of your research time in 1983 or 83/84 has been allocated to the following categories?

	Mission-oriented	Unconstrained by mandate or mission
pure/basic research		
applied research		

100

What, in your estimation, would be an appropriate mix of effort at a national level during the 1990's?

	Mission oriented	Unconstrained by mandate or mission
pure/basic research		
applied research		
		100

Comments:

6. Water problems cross disciplinary and professional boundaries, yet the structure of most government agencies and universities often mitigates against either interdisciplinary research or the integration of research results from various fields.

   (a) What percentage of your research work has been conducted in group efforts? ________

   (b) When you have been involved in group research, have the other individuals had a disciplinary or professional background similar to yours? ________

   (c) What action could the federal government take to encourage more interdisciplinary research in the future?

7. In a country as large and diverse as Canada, regional water resources issues may be quite different. What action could be taken to ensure that federal water resources research programs in the future respond more effectively to different regional needs?

8. What are the major constraints - shortage of funds, your time, shortage of professional personnel, shortage of technicians, inadequate space, inadequate equipment, or other (?) - to a larger role in water resources research in your organization? Please prioritize and comment briefly.

9. If your work has resulted in published papers, what percentage have been published in Canadian journals? ________________
   What are the reasons for your decisions for publishing in other than Canadian journals, when you have? What changes are needed to encourage you to publish more of your papers in Canadian journals in the future?

10. In your own research when considering the role of the federal government in water research in Canada, what are the most important issues and needs requiring attention in the years ahead? Please prioritize.

    What issues and needs receiving considerable attention over the last decade might, in your estimation, receive diminished attention in the next two decades?

Other comments/suggestions:

The following questions are intended for university-related people, although we welcome comments from any interested parties.

1. Should professors be allowed to "buy out" some of their teaching tasks (where some of the research money is used to hire other individuals to assume some (but not all) of the teaching responsibilities?)

2. How many proposals did you write and, of these, how many were funded during the reporting period? What was the major reason you prepared the number you did, and not more?

3. If you have a designated centre for water resources research at your university, please provide

   (a) its name: ____________________

   (b) date which it was established: ____________________

   (c) areas/fields of water resources research in which it has specialized: ____________________

   (d) number of employees in 1983: ____________________

   (e) status (is the centre a formal entity?) ____________________

4. From which sources did you receive funds to support graduate students (do not include scholarship-supported individuals) working in the field of water resources research?

NSERC	SSHRC	NRC	CMHC	ENV. CANADA IWD	OTHER FEDERAL (SPECIFY)	PROVINCIAL (SPECIFY)	PRIVATE SECTOR (SPECIFY)	OTHER
____	____	____	____			____		____

____________ SUM = 100%

Your efforts in completing the questionnaire are greatly appreciated.

Please return completed questionnaires to:

Professor Edward McBean
Department of Civil Engineering
University of Waterloo
Waterloo, Ontario, N2L 3G1

PROJECT QUESTIONNAIRE

1. Institution or Agency ....
   (Name and Address) ....
   ....

2. Reporting Year
   Note: The reporting period should be one year in length, either calendar year 1983, or where more convenient, the closest fiscal year (e.g., for federal agencies FY 1983-4).
   From .... (Month, Year)
   To .... (Month, Year)

PROJECT DATA

Note: Questions 3-13 below should be answered for each project active in the reporting year. This return provides space for up to three projects. For additional projects, either use additional forms or attach sheets with question numbers and answers.

3. Project Title (twenty words or less)..............................
   ....
   Brief description of purpose..............................
   ....

3. Project Title (twenty words or less)..............................
   ....
   Brief description of purpose..............................
   ....

3. Project Title (twenty words or less)..............................
   ....
   Brief Description of purpose..............................
   ....

Question		Project 1	Project 2	Project 3
4. Sub-category of research. Note: Enter the most applicable from categories on attached list		______	______	______
5. Name of project leader	Family	....	....	....
	Given	....	....	....
6. Work on reported project in reporting year. Enter man years (nearest 0.1 man year) for each indicated classification.	Doctor	______	______	______
	Master	______	______	______
	Bachelor	______	______	______
	Undergraduate and post-graduate assistants	______	______	______
	Technicians	______	______	______
7. Was project requested by another agency?	Check	Yes No	Yes No	Yes No
8. Was project co-operative with another agency during the reporting period? Note: A co-operative project is one in which two or more institutions or agencies are actively engaged in the research, or a second institution provides instruments and technical advice. If a second institution simply supports the project financially, the project would not be called co-operative	Check	Yes No	Yes No	Yes No
9. Duration of Project. This project commenced in	Month	....	....	....
	Year	19....	19....	19....
and is expected to be completed in	Month	....	....	....
	Year	19....	19....	19....
10. Project cost in reporting period. Note: Include only direct costs. Operating costs include salaries, travel and expendable equipment as typical items. Capital costs include instruments and observing platforms. Exclude capital depreciation costs and capital consumption allowances.	Operating $ Thousands	______	______	______
	Capital $ Thousands	______	______	______
	Total $ Thousands	______	______	______
11. Enter sources of the funds (total of 10 above) by approximate percentage distribution	Federal	______	______	______
	Provincial	______	______	______
	University	______	______	______
	Industry	______	______	______
	Other Canadian	______	______	______
	Specify	....	....	....
	Foreign	______	______	______
12. Using reporting year costs as 100, estimate costs in preceding and following years. (For example, if total cost of this project was 20% less in 1982 than in 1983 and the project was completed in 1983, enter 80 for 1982 and 0 for 1984)	1982	______	______	______
	1984	______	______	______
13. Attach a list of papers, reports and publications resulting from these projects, identifying each list by project title.				

Survey of Water Resources Research in Canada

REPORTING UNIT QUESTIONNAIRE

1. Institution or Agency .... Address ....

   ....

   Include name and address of reporting unit, section or division.

2. Reporting Year

   NOTE: The reporting period should be one year in length, either calendar year 1983, or where more convenient, the closest fiscal year (e.g., for federal agencies FY 1983-84).

   From .... Month .... Year

   To .... Month .... Year

3. Research Expenditures, by Water Resources Research sub-category for each year, 1982 to 1986.

   Group actual or forecast project costs according to sub-categories. For 1982 and 1983 enter also number of projects. If more than four sub-categories are reported, please use additional sheets.

   If reasonable estimates of "overhead" costs for space, power, senior administration etc. are readily available, include these in operating costs: Insert H after the entry if overhead charges are included.

   Exclude capital depreciation costs and capital consumption allowances.

   See attached page for research sub-categories.

Water resource research sub-category Code # ____

Year	1982 82/83	1983 83/84	1984 84/85	1985 85/86	1986 86/87
No. of Projects	____	____	X	X	X
			(projected)		
Expenditures in thousands $					
Operating	____	____	____	____	____
Capital	____	____	____	____	____
Total	____	____	____	____	____

Water resource research sub-category Code # ____

Year	1982 82/83	1983 83/84	1984 84/85	1985 85/86	1986 86/87
No. of Projects	____	____	X	X	X
			(projected)		
Expenditures in thousands $					
Operating	____	____	____	____	____
Capital	____	____	____	____	____
Total	____	____	____	____	____

Water resource research sub-category Code # ____

Year	1982 82/83	1983 83/84	1984 84/85	1985 85/86	1986 86/87
No. of Projects	____	____	X	X	X
			(projected)		
Expenditures in thousands $					
Operating	____	____	____	____	____
Capital	____	____	____	____	____
Total	____	____	____	____	____

Water resource research sub-category Code # ____

Year	1982 82/83	1983 83/84	1984 84/85	1985 85/86	1986 86/87
No. of Projects	____	____	X	X	X
			(projected)		
Expenditures in thousands $					
Operating	____	____	____	____	____
Capital	____	____	____	____	____
Total	____	____	____	____	____

4. Sources of funds 1983

   Enter percentage values (based on 1983 operating & capital = 100)

   Canadian: Federal ______ Provincial ______

   University ______ Industry ______

   Other Canadian ____ (Specify......................)

   Foreign ______

5. Professional Effort:
For reporting period.

For each relevant sub category of research, please list the discipline or professional background of the participants and enter the professional effort for the reporting period.

If additional space is required, please use additional sheet.

1983: Professional man years (nearest 1)

Sub-category Code Number	Discipline or Professional Background	Doctor	Master	Bachelor

6. Additions to Professional Staff 1983-85

Enter the annual additions to required professional staff, by highest earned degrees.

If additional space is required, please use additional sheet.

1983-4-5 Additions to Professional Staff

Discipline	Doctor			Master			Bachelor		
	1983	1984	1985	1983	1984	1985	1983	1984	1985

7. Technician Effort in man years
By field of training
For 1983 enter actual values.
For 1984,5 forecast the required annual addition.

Name of Field or Trade	Man years (nearest unit)		
	1983	1984	1985

8. Nature of projects planned to begin in 1985

8.1 Title and/or one-line description ....

....Sub-category of research code number..........

8.2 Title and/or one-line description ....

....Sub-category of research code number..........

8.3 Title and/or one-line description ....

....Sub-category of research code number..........

8.4 Title and/or one-line description ....

....Sub-category of research code number..........

8.5 Title and/or one-line description ....

....Sub-category of research code number..........

(Code from attached list)

We would appreciate receiving a copy of your annual report, if such is available.

University of Waterloo

Waterloo, Ontario, Canada
N2L 3G1

Faculty of Engineering
Department of Civil Engineering
519 885-1211

le 1er août 1984

Le Conseil des Sciences du Canada et l'Enquête en vue d'une politique fédérale en matiere d'eau sont les co-commanditaires de notre étude sur le statut de la recherche sur les ressources en eau au Canada. Une lettre confirmant cette commandite est annexée. Les objectifs de cette étude sont:

(1) fournir une mise à jour de l'inventaire des activités de la recherche sur l'eau au Canada pour 1983 ou avril 1983-mars 1984, qu'importe laquelle est appropriée à votre organisation, en identifiant l'effort des différentes catégories de recherches parmi le fédéral, le provincial, l'université et les secters privés.

(2) identifier les futurs besoins et priorités de recherches, et,

(3) évaluer les programmes fédéraux en termes de leur capacité à répondre aux changements de priorités de la recherche sur les ressources en eau, leur coordination et leur gestion au Canada.

Les sources étant contactées pour cette information sont des individus et des organisations impliqués dans la recherche sur les ressources en eau partout au Canada.

Nous apprécierions que vous nous envoyez l'information au sujet de la recherche sur les ressources en eau de votre département.

Deux questionnaires sont inclus. Le questionnaire de l'unité de rapport est utilisé pour recueillir l'information sur le coût global et la main-d'oeuvre. Le questionnaire sur le projet est utilisé pour recueillir l'information décrivant les projets de recherches individuels. Ces questionnaires devraient être distribués aux individus responsables des projets de recherches particulier.

Nous sommes au courant que Bruce et Maasland ont publié un rapport pour le Conseil des Sciences du Canada sur le statut des ressources en eau au Canada en 1968 et qu'en 1979 Environnement Canada avait mis à jour leur inventaire. Plusieurs personnes, partout au Canada, ont pris un temps considérable pour fournir les données essentielles de ces études. Notre devoir, en dirigeant cette troisième étude, implique la soumission d'un rapport au début de 1985, à la fois mettant à jour l'inventaire, et en identifiant les futures issues, opportunitées,contraintes et stratégies relatives à la recherche sur les ressources en eau au Canada. Les résultats de cette enquête seront utilisés par l'Enquête en vue d'une politique fédérale en matière d'eau.

Bien que nous demandons les noms des chercheurs, cette information sera utilisé seulement pour faciliter la catégorisation et le traitement. Les réponses seront traitées confidentiellement et aucun individu ne sera identifié par son nom dans le rapport.

Pour que les réponses de votre département soit prise en compte totalement, nous avons besoin de recevoir le questionnaire compléter au plus tard le 14 septembre 1984. En somme, nous espérons que vous les distriburez aussi vite que possible à vos chercheurs, et leur faire part de l'importance de recevoir leur commentaires.

Si vous avez des questions, s'il vous plaît, n'hésitez pas à nous contacter. S'il vous plaît, retourner votre correspondance à:

Professor Edward McBean
Department of Civil Engineering
University of Waterloo
Waterloo, Ontario, N2L 3G1

Sincèrement

Bruce Mitchell,
Professor of Geography
(519) 885-1211 (Ext. 3064)

Sincèrement

Edward McBean,
Professor of Civil Engineering
(519) 885-1211 (Ext. 3349)

Science Council of Canada Conseil des sciences du Canada

LE CONSEIL DES SCIENCES DU CANADA ET LA COMMISSION D'ENQUÊTE SUR LA POLITIQUE FÉDÉRALE DE L'EAU

ENQUÊTE SUR LA RECHERCHE DANS LE DOMAINE DE L'EAU

Au cours des années 60, le Conseil des sciences du Canada a entrepris une étude importante relative aux recherches sur les ressources en eau, étude qui a donné lieu à la publication en 1968 de l'étude de documentation n° 5, effectuée par Bruce et Maasland et intitulée La recherche dans le domaine de l'eau au Canada, et du rapport du Conseil n° 3 intitulé Un programme majeur de recherches sur les ressources en eau du Canada. De nouvelles questions (la pollution causée par les produits chimiques toxiques, les transferts entre bassins) prennent de plus en plus d'importance et exigent une réévaluation des besoins en matière de recherche dans le domaine de l'eau d'ici l'an 2000. Il y a quelques années, Environnement Canada a organisé plusieurs ateliers en vue d'étudier quelques questions pertinentes, mais non l'orientation future des recherches dans le domaine de l'eau. Le Conseil des sciences envisage donc d'approfondir davantage la question.

Fort de l'autorisation du Cabinet, le ministre de l'Environnement a récemment établi une Commission d'enquête sur la politique fédérale de l'eau, formée de trois membres et présidée par le D^r Peter Pearse. La Commission d'enquête a pour mandat de se renseigner à fond auprès des Canadiens et de leurs gouvernements; d'établir la nature des nouvelles questions; d'évaluer la quantité d'eau actuellement disponible ainsi que les besoins futurs en ce qui touche la conservation et l'utilisation de l'eau, et "d'évaluer les besoins et la nature des compétences additionnelles nécessaires en sciences et en recherches dans le domaine de la gestion des ressources en eau au Canada".

Vu leur intérêt commun à l'égard des futures activités de recherche dans le domaine de l'eau, la Commission d'enquête et le Conseil des sciences ont accepté de parrainer conjointement des travaux dans ce domaine et ont conclu un marché avec MM. Edward McBean et Bruce Mitchell, professeurs à l'Université de Waterloo, aux fins d'exécution du projet.

Ce projet mixte a pour but de :

1. Mettre à jour le répertoire des activités de recherche dans le domaine de l'eau à partir des rapports publiés en 1968 par le Conseil des sciences et du document publié en 1979 par Environnement Canada, déterminer les modifications apportées aux travaux exécutés dans les divers domaines de recherche ainsi que les modifications des travaux et du financement dans les secteurs fédéral, provinciaux, universitaires et privés.

...2

2. Déterminer les priorités et les besoins futurs en matière de recherche, en tenant compte des tendances actuelles et des nouvelles questions dans le domaine de l'eau, établies par la Commission d'enquête sur la politique fédérale.

3. Évaluer les programmes de recherche fédéraux en ce qui touche leur capacité de s'adapter aux priorités changeantes de la recherche, de la coordination et de la gestion des ressources en eau au Canada.

Conseil des sciences du Canada

July 13, 1984

D.E. Read
Conseiller scientifique

Commission d'enquête sur la politique fédérale de l'eau

Frank Quinn
Directeur de la recherche

Questionnaire de l'unité de rapport

1. Institution ou agence .... Adresse ....

   ....

   Inclure nom et adresse de l'unité de rapport, section ou division

2. Année rapportée — De.......... Mois .... Année — A .... Mois .... Année

   NOTE: La période rapportée devrait être d'une durée d'un an, soi l'anneé du calendrier 1983, ou la fin de l'anneé fiscale, là ðu c'est plus -pratique (e.g., pour les agences fédérales, l'anneé fiscale 1983-4)

3. Dépenses de recherche sur les ressources en eau par sous-catégorie de recherche pour chaque année 1982 - 1986.

   Groupe actuel ou coûts de projet prévu selon les sous-catégories. Pour 1982 et 1983 indiquez aussi le nombre de projets. Si plus de 4 sous-catégories sont rapportées, s'il vous plaît, utiliser des feuilles additionnelles.

   Si des estimations raisonnables des coûts de vos frais généraux (overhead) pour l'espace, l'énergie, l'administration supérieure, etc., sont facilement disponible, inclure ceux-ci dans les coûts de fonctionnement. Inscrivez la lettre H a côté du chiffre si les frais généraux (overhead) sont inclus

   Exclure les coûts de capital pour la dépréciation et les allocations de capital pour les fournitures.

   Voir la feuille ci-jointe pour les sous-catégories de recherche.

Recherche sur les ressources en eau sous-catégorie Code # ________

Anneé	1982 82/83	1983 83/84	1984 84/85	1985 85/86	1986 86/87
Nombre de projets	____	____	X	X (projet)	X
Dépenses en milliers $					
Fonctionnement	____	____	____	____	____
Capital	____	____	____	____	____
Total	____	____	____	____	____

Recherche sur les ressources en eau sous-catégorie Code # ________

Anneé	1982 82/83	1983 83/84	1984 84/85	1985 85/86	1986 86/87
Nombre de projets	____	____	X	X (projet)	X
Dépenses en milliers $					
Fonctionnement	____	____	____	____	____
Capital	____	____	____	____	____
Total	____	____	____	____	____

Recherche sur les ressources en eau sous-catégorie Code # ________

Anneé	1982 82/83	1983 83/84	1984 84/85	1985 85/86	1986 86/87
Nombre de projets	____	____	X	X (projet)	X
Dépenses en milliers $					
Fonctionnement	____	____	____	____	____
Capital	____	____	____	____	____
Total	____	____	____	____	____

Recherche sur les ressources en eau sous-catégorie Code # ________

Anneé	1982 82/83	1983 83/84	1984 84/85	1985 85/86	1986 86/87
Nombre de projets	____	____	X	X (projet)	X
Dépenses en milliers $					
Fonctionnement	____	____	____	____	____
Capital	____	____	____	____	____
Total	____	____	____	____	____

4. Sources de fonds en 1983

   Entrer les valeurs en pourcentage (basé sur le fonctionnement et le capital en 1983 = 100)

   Canadien: Fédéral__________ Provincial______________

   Université__________ Industrie __________

   Autre source canadienne _____ (Spécifiez...............)

   Source étrangère ____________________

1983: Effort professionnel en homme par année (le plus rapproché de 1)

5. Effort professionnel: Pour la période rapporteé

Pour chaque sous-catégorie de recherche pertinente, s'il vous plaît, donner la discipline ou la formation professionnelle des participants et notifier l'effort professionnel pour la période rapportée.

Si de l'espace additionnelle est requise, s'il vous plaît, utiliser une feuille supplementaire.

Numéro de code de la sous-catégorie	Discipline ou formation professionnelle	Doctorat	Maitrise	Baccalauréat

6. Additions au personnel professionnel 1983-85

Notifier les additions annuelles requises au personnel professionnel par les plus haut degrés gagnés.

1983-4-5 Additions au personnel professionnel

Discipline	Doctorat			Maitrise			Baccalauréat		
	1983	1984	1985	1983	1984	1985	1983	1984	1985

7. Effort des techniciens en homme par année par champ de formation. Pour 1983, inscrivez les valeurs actuelles. Pour 1984,5, prévoyez l'addition annuelle requise.

Nom du champ ou métier	Homme par année (le plus près de l'unité)		
	1983	1984	1985

8. Nature des projets prévus pour le début de 1985

8.1 Titre et/ou description en une ligne ....

.....................Numéro de code de la sous-catégorie de recherche..............

8.2 Titre et/ou description en une ligne ....

.....................Numéro de code de la sous-catégorie de recherche..............

8.3 Titre et/ou description en une ligne ....

.....................Numéro de code de la sous-catégorie de recherche..............

8.4 Titre et/ou description en une ligne ....

.....................Numéro de code de la sous-catégorie de recherche..............

8.5 Titre et/ou description en une ligne ....

.....................Numéro de code de la sous-catégorie de recherche

(Code venant de la liste ci-jointe)

Nous apprécierions reçevoir une copie de votre rapport annuel, si disponible.

Relevé de la recherche sur les ressources en eau au Canada

QUESTIONNAIRE SUR LE PROJET

1. Institution ou agence ....

(Nom et adresse) ....

2. Année rapportée
Note: La période rapportée devrait être d'une durée d'un an, soi l'année du calendrier 1983, ou la fin de l'année fiscale, là où c'est plus pratique (e.g., pour les agences fédérales, l'année fiscale 1983-4).

De ....
Mois Année
A
....
Mois Année

Données sur le projet

Note: Les questions 3 à 13 ci-dessous devrait être répondu pour chaque projet actif de l'année rapportée. Cette feuille de retour fournis de l'espace pour un maximum de trois projets. Pour des projets additionnels, utilisé soi des formulaires additionnels ou joindre des feuilles supplémentaires avec les numéros des questions et des réponses.

3. Titre du projet (vingt mots ou moins)..

....

Brève description de l'objectif..

....

3. Titre du projet (vingt mots ou moins)..

....

Brève description de l'objectif..

....

3. Titre du projet (vingt mots ou moins)..

....

Brève description de l'objectif..

....

4. Sous-catégorie de recherche Note: inscrivez les catégories les plus applicable de la liste ci-jointe				
5. Nom du directeur du projet	Nom	....	....	....
	Prénom	....	....	....
6. Travail sur le projet mentionné dans l'année rapportée	Doctorat			
	Maitrise			
	Baccalauréat			
	Assistants sous-gradués et post-gradués			
	Techniciens			
7. Est-ce que le projet était sollicité par une autre agence?	Encerclez	Oui Non	Oui Non	Oui Non
8. Est-ce que le projet était en coopération avec une autre agence durant la période rapportée? Note: Un projet coopératif est un projet dans le quel 2 institutions ou agences ou plus sont activement engagés dans la recherche, ou une deuxième institution fournie des instruments et des moyens techniques. Si une deuxième institution supporte simplement le projet financièrement, le projet ne serait pas appelé coopératif.	Encerclez	Oui Non	Oui Non	Oui Non
9. Durée du projet. Ce projet à débuté en	Mois	....	....	....
	Année	19....	19....	19....
et est prévu être terminé en	Mois	....	....	....
	Année	19....	19....	19....
10. Coût du projet dans la période rapportée. Note: Inclure seulement les coûts directs. Les coûts de fonctionnement incluent les salaires, les voyages et l'entretien de l'équipement comme articles typique. Les coûts de capital incluent les instruments et les plateformes observantes. Exclure les coûts de capital pour la dépréciation et les allocations de capital pour les fournitures.	Fonctionnement $ Milliers			
	Capital $ Milliers			
	Total $ Milliers			
11. Inscrivez les sources de fonds (total de la question 10 ci-dessus) par le pourcentage approximatif de distribution.	Fédéral			
	Provincial			
	Université			
	Industrie			
	Autre source canadienne (Spécifiez)			
		....	....	....
	Source étrangère			
12. En utilisant les coûts de l'année rapportée comme 100, estimez les coûts des années précédentes et suivantes. (Par exemple, si le coût total du projet était de 20% moins en 1982 qu'en 1983 et le projet était terminé en 1983, entrez 80 pour 1982 et 0 pour 1984).	1982			
	1984			
13. Annexez une liste des articles, des rapports et des publications résultants de ces projets, en identifiant chaque liste par le titre du projet.				

EVALUATION DES BESOINS DE RECHERCHE

Comme avec tous les questionnaires, leur distribution doivent être limités. Cependant, des réponses obtenues, nous devons extrapoler l'information pour caractériser sur la scène nationale, la recherche sur les ressources en eau au Canada. Ceci n'est pas une tâche qui est simple, ni une tâche à prendre à la légère, dû aux dangers important d'ommission et de duplication. Ainsi, quand vous complèterez le questionnaire, s'il vous plait garder en mémoire:

(i) la responsabilité de la recherche que vous reportez est pour:
e.g. (a) vous comme un individu
(b) la section, division ou unité dans laquelle vous travaillez
(c) autre (spécifiez)

(ii) le questionnaire étant complété par un groupe de personnes avec différentes formations, cette manière impliquant quelques questions pouvant être plus directement applicable à vous qu'à d'autres.

1. Selon vous, quels sont les besoins et les priorités en matière de recherche sur les ressources en eau au Canada présentement et d'ici l'an 2000? Quelles issues sont probablement les plus importantes dans les années 1990 et que devrions nous faire en recherche maintenant afin d'être prêt à faire face a ces issues dans les anneés 1990?

2. Quels changements devrions nous faire pour améliorer la capacité des programmes de recherche fédéraux afin de répondre aux priorités de changements pour la recherche sur les ressources en eau?

3. Quels changements devrions nous faire pour améliorer la coordination des programmes fédéraux de recherche sur les ressources en eau apparenté aux différentes activités de recherche parmi les différents départements fédéraux ainsi que les gouvernements provinciaux, les universités et le secteur privé?

4. Est-ce que les résultats de la recherche sur les eaux au Canada sont effectivement appliqués à la résolution de problèmes pratique? Si non, quels sont les obstacles principaux à leur application? Que devrions ou pourrions nous faire pour améliorer l'utilisation des résultats de recherche sur les eaux dans les années 1990 afin de résoudre des problèmes pratiques?

5. Dans la planification et la direction de la recherche sur les ressources en eau, quelle proportion de votre temps de recherche en 1983 ou 83/84 a été alloué aux catégories suivantes?

	Mission Orientée	Sans contrainte par mission ou mandat	
Recherche pure et fondamentale			
Recherche appliquée			
			100

Selon votre estimation, quel serait un effort mixte approprié à un niveau national durant les années 1990?

	Mission Orientée	Sans contrainte par mission ou mandat	
Recherche pure et fondamentale			
Recherche appliquée			
			100

Commentaires:

6. Les problèmes de l'eau croisent des frontières disciplinaires et professionnelles, encore que la structure de la plupart des agences gouvernementales et des universités apaise souvent l'autre recherche interdisciplinaire ou l'intégration des résultats de recherche de différentes activités.

   (a) Quel pourcentage de votre travail de recherche a été fait dans un travail d'équipe? __________

   (b) Quand vous avez été impliqué dans un groupe de recherche est-ce que les autres individus avaient une formation disciplinaire ou professionnelle similaire à la votre? ____________________

   (c) Quel action le gouvernement fédéral pourrait-il prendre pour encourager encore plus, dans le futur, la recherche interdisciplinaire?

7. Dans un pays aussi vaste et diversifié que le Canada, les issues régionales de ressources en eau peuvent etre bien différentes. Quel action pourrait bien prendre le fédéral pour assurer que les programmes de recherches sur les ressources en eau répondent, dans le futur, plus efficacement aux différents besoins régionaux?

8. Quelles sont les contraintes majeures - manque de fonds, votre temps, manque de personnel professionnel, manque de techniciens, espace inadéquat, équipment inadéquat ou autre (?) - qui jouent un vaste role dans la recherche sur les ressources en eau dans votre organisation? S'il vous plaît indiquer les priorités et commenter brièvement.

9. Si votre travail a résulté en publications, quel pourcentage a été publié dans des journaux canadiens? Quelles sont les raisons de vos décisions de publier dans des journaux autre que canadiens, quand ils existent? Quels changements sont nécessaires pour vous encourager de publier plus, dans le futur, dans des journaux canadiens?

10. Dans votre propre recherche, quand vous considérez le role du gouvernement fédéral dans la recherche en eau au Canada, quels sont les issues les plus importantes et les besoins demandant une attention dans les prochaines années? S'il vous plaît, indiquer les priorités.

    Quels issues et besoins recevants une attention considérable durant la dernière décade pourrait, selon votre estimation, recevoir une attention moindre dans les 2 prochaines décades?

Autres commentaires/suggestions:

Les questions suivantes sont destinées aux personnes en relation avec l'université, bien que nous souhaitons les commentaires de tous autres partis intéressés.

1. Est-ce que les professeurs devraient avoir la permission d'acheter à l'extérieur (buy out) une partie de leur tâche d'enseignement (où une partie de l'argent de recherche est utilisé pour engager d'autres individus pour assumer une partie (mais pas en totalité) des responsabilités d'enseignement?)

2. Combien de propositions de recherche avez vous écrit et, de ceux-ci, combien ont été consolidé durant la période rapportée? Quelle était la raison majeure pour laquelle vous avez préparé le nombre que vous avez rapporté et pas plus?

3. Si vous avez un centre désigné pour la recherche sur les ressources en eau à votre université, s'il vous plaît, fournisser:

   (a) son nom: ______________________

   (b) la date à laquelle il a été établi: ______________________

   (c) sujets/champs d'activités de la recherche sur les ressources en eau dans lequel il est spécialisé: ______________________

   (d) le nombre d'employés en 1983

   (e) le statut (est-ce que le centre a une entité formelle?)

4. De quelles sources avez vous recu vos fonds pour supporter vos étudiants gradués (ceci n'inclus pas les boursiers et les individus supportés par eux-mêmes) travaillant dans le champ de la recherche sur les ressources en eau?

CRSNGC	CRSHC	CNR	SCHL	ENV. CANADA DGEI	FEDERAL AUTRE (SPECIFIEZ)	PROVINCIAL (SPECIFIEZ)	SECTEUR PRIVE (SPECIFIEZ)	AUTRE

______________ TOTAL = 100%

Vos efforts en vue de compléter le questionnaire sont grandement appréciés.

S'il vous plaît, retourner vos questionnaires complétés à:

Professor Edward McBean
Department of Civil Engineering
University of Waterloo
Waterloo, Ontario, N2L 3G1

APPENDIX II

ATTENDEES AT THE WORKSHOP

APPENDIX II

Listed below are the participants involved in the workshop held in Kitchener in November 1984. Indicated also are the individual's affiliation as of the workshop dated.

P. Ashton	Intergroup Consulting Economists Ltd. Winnipeg
B. Ayles	Freshwater Institute Fisheries and Oceans Winnipeg
R.D. Bailey	Water Resources Division Department of Indian & Northern Affairs Ottawa
W.F. Cardy	Water Resources Branch Environment New Brunswick Fredericton
A.H.J. Dorcey	Westwater Research Centre University of British Columbia Vancouver
M. Gilbertson	Fish Habitat Management Branch Ottawa
D.H. Lennox	National Hydrology Research Institute Environment Canada Ottawa
F. Quinn	Inquiry on Federal Water Policy Ottawa
D. Read	Science Council of Canada Ottawa
H. Regier	Institute for Environmental Sciences University of Toronto Toronto
G.K. Rodgers	National Water Research Institute Environment Canada Burlington
M. Slivitsky	INRS - Eau Ste-Foy, P.Q.
G.C. Topp	Land Resource Research Institute Agriculture Canada Ottawa

J. Whiting	Saskatchewan Research Council Saskatoon
S.O. Winthrop	Environmental Health Directorate Health and Welfare Canada Ottawa
B. Mitchell (Convener)	Department of Geography University of Waterloo Waterloo
E. McBean (Convener)	Department of Civil Engineering University of Waterloo Waterloo

Inquiry on Federal Water Policy

Enquête sur la politique fédérale relative aux eaux

Research Papers

Documents de recherche

ALTERNATIVE FUTURES OF CANADIAN WATER USE 1981-2011

by

Donald M. Tate

Canada

Inquiry on Federal Water Policy
Research Paper # 17

ALTERNATIVE FUTURES OF CANADIAN WATER USE 1981-2011

by

Donald M. Tate

Inland Waters Directorate
Environment Canada
Hull

May 1985

THE INQUIRY ON FEDERAL WATER POLICY

The Inquiry on Federal Water Policy was appointed by the federal Minister of the Environment in January of 1984 under the authority of the Canada Water Act. The members were Peter H. Pearse, chairman; Françoise Bertrand, member; and James W. MacLaren, member. The Inquiry was required by its terms of reference to review matters of water policy and management within federal jurisdiction and to make recommendations.

This document is one of a series of research papers commissioned by the Inquiry to advance its investigation. The views and conclusions expressed in the research papers are those of the authors. Copies of research papers and information on the series may be obtained by writing to the Enquiry Centre, Environment Canada, Ottawa, Ontario K1A 0H3.

Frank Quinn

Frank Quinn
Director of Research

Abstract

Projections of withdrawal water use in Canada, its five major regions and 47 major river basins are contained in this research report. The time period covered by the forecasts carried out here is 1981-2011. The methodology used is based upon structural modelling, employing a thirty-sector regional input-output model, augmented for use in a water demand projection mode. Major variables used in the forecasting were economic activity levels, production technology and water use practices, as defined in the first chapter. The effects of a concerted effort at promoting water conservation were also modelled.

An alternative approach to the forecasting problem is outlined in chapter five, using the Red Deer River basin as a hypothetical case study. The advantages of this simulation modelling approach relate to the integration into the water use forecasting process of water supply considerations, and the ability to conduct studies on a river basin and subbasin level, as opposed to an economic region level.

Six recommendations for further work are made in the final chapter.

Résumé

Ce rapport de recherche contient des projections sur l'utilisation de l'eau hors de son cours normal pour le Canada, pour chacune de ses cinq régions majeures et pour chacun de ses 47 bassins principaux. Ces prévisions couvrent la période 1981-2011. La méthodologie utilisée repose sur l''emploi d'une modélisation structurée elle-même basée sur un modèle régional d'entrée-sortie à 30 secteurs; ce modèle a été modifié afin d'être utilisable dans le domaine de la projection de la demande en eau. Les principales variables utilisées pour ces prévisions sont les niveaux d'activité économique, la technologie de production et les pratiques habituelles d'utilisation tel que décrites au chapitre 1. Les effets d'un effort concerté afin de promouvoir la conservation de l'eau ont aussi été modelisées.

Une approche différente du problème de la prévision est décrite au chapitre 5. Le bassin de la rivière Red Deer y est utilisé comme étude de cas hypothétique. Les avantages de cette approche simulative sont liés à l'intégration dans le processus de prévision de considérations sur les approvisionnements en eau de même qu'à la possibilité de faire des études au niveau du bassin et des sous-bassins d'une rivière par opposition à la simulation à l'échelle d'une région économique. Le dernier chapitre contient six recommandations quant aux travaux futurs dans ce domaine.

Summary

Projections of withdrawal water use in Canada, its five major regions and 47 major river basins are contained in this research report, commissioned by the Inquiry on Federal Water Policy. The time period covered by the forecasts carried out here is 1981-2011. The methodology used is based upon structural modelling, employing a thirty-sector regional input-output model, augmented for use in a water demand projection mode. Major variables used in the forecasting were economic activity levels, production technology and water use practices, as defined in the first chapter. The effects of a concerted effort at promoting water conservation were also modelled. The range of expected withdrawal and consumptive water uses for Canada and the regions to 2011 are shown in tabular form as follows.

EXPECTED RANGES OF WATER USE, CANADA AND REGIONS
1981-2011 (MCM)

Region		Intake		Consumption	
		Low*	High**	Low*	High**
B.C.	1981	3789	3789	487	487
	1991	3950	5043	512	645
	2001	3989	6623	508	850
	2011	3726	8057	464	1046
Prairie	1981	5363	5363	2256	2256
	1991	6167	7569	2494	3172
	2001	6580	10158	2485	4227
	2011	6687	12895	2262	5318
Ontario	1981	21230	21230	589	589
	1991	23987	28355	711	776
	2001	26925	38146	649	1031
	2011	29235	48258	625	1291
Québec	1981	4252	4252	435	435
	1991	4523	5514	428	525
	2001	4567	7184	417	661
	2011	4327	8901	380	804
Atlantic	1981	2884	2884	139	139
	1991	3222	3795	150	179
	2001	3529	4902	153	223
	2011	3764	5929	151	263
Canada	1981	37518	37518	3906	3906
	1991	41848	50275	4292	5298
	2001	45589	67011	4212	6990
	2011	47738	84039	3882	9025

* Scenario 2, as defined in Chapter three
** Scenario 5, as defined in Chapter three.

An alternative approach to the forecasting problem is outlined in Chapter five, using the Red Deer River basin as a hypothetical case study. The advantages of this simulation modelling approach relate to the integration into the water use forecasting process of water supply considerations, and the ability to conduct studies on a river basin and subbasin level, as opposed to an economic region level.

Six recommendations for further work are made in the final chapter. In summary form, these are:

1. The major focus of future water demand studies at the federal level should be at the major river basin level, and should be oriented toward comparing available supplies with current and projected uses, using a simulation modelling approach such as that suggested in Chapter five.
2. The structural model of Chapter two should be developed further in order to obtain regional overviews of emerging water demands.
3. The range of alternatives for water conservation and their impacts on water demand should be studied and assessed with regard to their impacts in reducing water demand.
4. The impacts on water demand of emerging production technology may be substantial, and should be examined beyond the analysis contained in this report.
5. Water use data for industries and municipalites should continue to be collected on a regular basis to provide basic information for future water demand forecasting exercises.
6. Research should be carried out to integrate nonwithdrawal water uses into the forecasting framework established in this report.

ACKNOWLEDGEMENTS

This project was made possible only with the assistance of several persons. Ms. P. Dossett served as research assistant throughout the project, and performed most of the mathematical computations and graphical presentations contained in the report. Dr. A. Kassem co-ordinated most of the work carried out in Chapter 5. These persons also provided useful day-to-day discussions and advice. D. Scharf, D. Lacelle and P. Hess provided much of the data on current water use on which the study is based. Ms. C. Lefebvre provided clerical assistance throughout the project. Finally, the Advisory Committee established for the project provide many useful ideas and suggestions. Members of this committee were Dr. Duane Baumann, Dr. Peter Harrison, Mr. Clive Simmonds, Mr. Carl Sonnen, Mr. Bruce Stokes, Mr. Douglas Vallery and Dr. Terry Veeman. Any errors or ommissions in the report, of course, are my responsibility.

D. Tate

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CHAPTER 1

INTRODUCTION

1.1 Need for the Project

The use of water is one of the most fundamental transactions between man and nature. It is an integral part of most of man's activities, and, in turn, water is affected greatly by man's use of the resource. When considering the economic and social development of a nation, one important but often underplayed issue relates to water use. Will there be enough water to support development? Will it be of adequate quality, in the right location, and available at the right time to be of use? Can society achieve the desired degree of development while preserving and conserving available water resources? Are water transfers required to achieve development? In answering these and other equally important questions, one fundamental piece of required information is a set of water use projections over a fairly long term period (e.g. thirty years).

1.2 Purpose of the Project

This project is one of a series of research investigations commissioned by the Inquiry on Federal Water Policy (the "Inquiry"). The overall purpose is to forecast water uses in Canada, its five regions and its major river basins to the year 2011. The forecasts will be broken down to the latter level to facilitate comparison of future water uses with supply conditions. The latter task is assumed here to be one of the analyses to be carried out by the Inquiry staff.

The remainder of this chapter deals with the scope of the project. Chapter two contains a detailed discussion of the methodological framework used in this research. It may be skipped if the reader is interested only in the substantive findings. Chapter three documents the selection of alternative futures which underlie the water use forecasts. The results of the principal research investigations of this project are outlined and discussed in Chapter four. Based upon limitations identified in this chapter and on research currently underway but not yet completed, Chapter five outlines an alternative forecasting approach. Finally, Chapter six draws the major conclusions and implications from the study. The water use forecasts themselves plus the background of historical water use constitute the principal conclusions of the report. It is beyond the scope of this project to draw conclusions about water supply:use imbalances across the country.

1.3 Scope of the Project

1.3.1. Forecasting Time Horizon

As noted above, the water use forecasts prepared during this project cover the 30-year period 1981-2011. This time period posed many problems of uncertainty, which will be discussed below. In spite of these problems, a thirty year period is required in view of at least three factors. First, water projects require lengthy planning and implementation periods. These long planning and construction times required in the water resource field stand in marked contrast to most business decisions, which require shorter implementation times, and therefore shorter forecasting

horizons. Second, water related structures are permanent and expensive capital assets and, accordingly, should be planned with some idea in mind of future water use conditions over the long term. Third, water projects tend to affect many persons and activities for long periods of time. Thus, again, good planning requires a long range view of the future.

The chief implication of a 30-year forecasting period is a large degree of uncertainty. While water use forecasts can be prepared simplistically by extrapolating past trends, such procedures are of limited usefulness. Trend is definitely not destiny, and much of the work in any water use forecasting exercise must be devoted to attempting to cope with economic, social, technological and policy uncertainties in the future.

1.3.2. <u>Basic Approaches to Forecasting</u>

Study of the future and the preparation of forecasts has grown over the past two decades into a virtual industry, with its set of academic journals, university courses and frequent conferences. Although the array of forecasting techniques is formidable, it can be divided into those techniques which are analytic in nature, and those which can be termed futuristic.

The analytical techniques involve detailed computer models, large amounts of quantitative data and a general reliance on the traditional logical positivist approach to the subject. Forecasts tend to rely on those variables which can be quantified, and the effects of factors such as lifestyle variations, social trends and other unquantifiable variables are downplayed. The advantages of analytic procedures for forecasting lie in the

quantitative answers which are produced, the availability of computer techniques and the built-in logical relationships between variables. Disadvantages are several and substantial. The forecasts are at best partial in nature, for only those variables modelled can be displayed. Significant changes in the society in lifestyles or social attitudes may be equally significant to the quantified factors in changing water use and yet remain unconsidered.

Futuristics, on the other hand, tends to be a broader and more wholistic approach than analytic modelling. The approach considers not only trends which are quantifiable, but also broader issues, such as the social context of the future, lifestyles, ethics and philosophies. Being wholistic in nature, futuristic approaches are more difficult to model mathematically. Rather, techniques such as Delphi panels, content analysis, and "brainstorming" are used.

The distinction between these two classes of techniques is of interest here because this project is based very much on the analytical approach. Variables which are quantifiable and which are thought to be important in determining the level of water use in various activities have been combined in a mathematical model to produce quantitative forecasts. Unquantifiable factors have been omitted. Also, the forecasts contained here are "positive" in nature, in that they show what would happen to water use if specified conditions emerge. This stands in contrast to so-called "normative" forecasts which focus upon specifying what should occur to achieve specified goals (e.g. maximum economic growth).

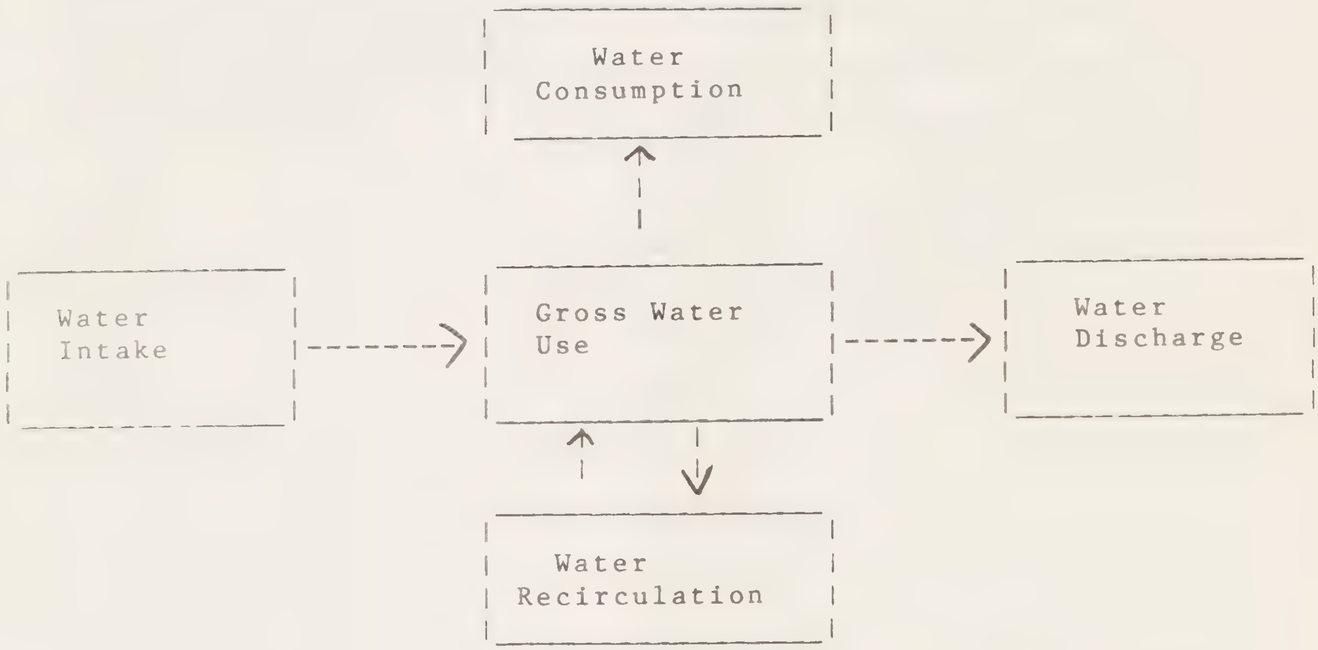
Normative forecasting has not been attempted here because it has not been posible to prescribe the ideal future or to define even the most desirable social goals to be sought. In some quarters, the output of this exercise would be termed "projections", not forecasts. No distinction has been made in this report between these terms.

1.3.3. Water Use Types and Definitions

In discussions of water use, a distinction is commonly drawn between withdrawal and nonwithdrawal uses. Withdrawal uses refer to those activities, such as the provision of municipal or industrial water supplies, which take water from some ambient water source, use it as required, and return some or all of it to the ambient source. Nonwithdrawal uses employ characteristics of the water resource as it occurs in its natural state. Common examples of the latter type of usage are hydroelectric power generation and water-based recreation. The distinction between these two types of usage is important here, because this research pertains mainly to the former type of use. Many of the concepts employed here would be inappropriate for a study of nonwithdrawal water use.

In collecting data and conducting research on industrial water use, the following concepts have been used (Figure 1.1). Water is taken into a plant by way of some type of intake system composed of pipes, pumps and intake treatment. The amount of water taken in for first time use is termed "water intake" or simply "intake". To produce a product or service, some total amount of water is used; this amount is referred to as "gross

FIGURE 1.1 A GENERALIZED DIAGRAM OF AN INDUSTRIAL PLANT WATER SYSTEM



water use". The arithmetic difference between water intake and gross water use is made up of "water recirculation". In their use of water, all users are considered as having water intake and gross water use; not all recirculate water. Many relatively small users and some users adjacent to large water bodies may employ "once through" water systems, in which water is taken into the plant, used and discharged, with no recirculation at all.

The ratio of gross water use to water intake is called the "use rate", and is an index of water recirculation in a plant of activity. The minimum value of the use rate is 1.0 (for once through systems); the ratio increases as more and more water is

recirculated, and may reach values of 15 or higher. To quantify the amount of water recirculated, on the survey which constitutes the major source of water data for this project (Canada, 1985), industrial firms were asked to estimate the amount of water which would have been required had there been no recirculating system; this amount is the gross water use at the plant. From this amount was deducted the amount of water intake, the residual being taken as the amount of recirculation.

On the discharge side of a typical plant water circulation system three components are apparent. "Water discharge" is the amount of water put back into receiving waters after use, and, in many cases, subsequent to some form of waste treatment. The arithmetic difference between water intake and water discharge is termed "water consumption". The third discharge component of the system is composed of water recirculation, discussed in the previous paragraph. The ratio of water consumed: water intake is called the "consumption rate" and varies in value between 0 and 1.

In making comparisons of water use with available water supplies, both intake (Canada, 1972) and consumption (Wolman and Bonem, 1971) have been used. Neither measure is completely satisfactory. Water intake denotes the total instantaneous withdrawal from an ambient water source by a given set of industries. Most or, in some cases, all of this water is returned to the watercourse from which it was withdrawn, and therefore does not constitute a "loss" to water quantity. Alterations which may occur as the result of industrial use, such

as water quality degradations, are acknowledged but not addressed in this report.

Water consumption, in contrast, is a measure of water apparently lost during a plant's operation, consisting of components such as evaporative losses, water incorporated into products, water removed from the plant site to landfill sites, and other such losses. The concept of water consumption thus measures the water loss at a particular location. But this concept does not necessarily indicate losses to the water resource system as a whole, even in a local area. Evaporative losses may fall subsequently as precipitation; products which incorporate part of plant water intake may be used in the local area, with the water re-entering the watercourse near the plant; water in wastes deposited in local landfill sites will eventually re-enter the local water system. Thus, water consumption may not be a true indicator of water loss to the local or regional water supplies. As used here, the concept of water consumption is relative to the industrial operation itself and not to the concept of the hydrologic cycle.

1.3.4. Spatial Focus

The research consisted of two separate spatial contexts. Most of the work was performed at the national and regional levels. The regional level refers to the five major Canadian political-economic regions: the Atlantic (Newfoundland, Prince Edward Island, Nova Scotia and New Brunswick), Quebec, Ontario, the Prairies (Manitoba, Saskatchewan and Alberta) and British Columbia. The two Northern Territories were not included because

they contained a negligible amount of withdrawal water use, and because water use:supply balances are generally not a problem in these areas. The national:regional work was carried out to provide a uniform set of forecasts for the major regions of the country. The regional forecasts were broken down on the basis of current proportions into estimates of future water use for each major river basin. The basin estimates were considered to reflect the water use of the entire basin area, and may be used in making preliminary supply:use comparisons.

1.3.5. Economic Sectors

The national:regional model was built to be comprehensive in its coverage of economic sectors. Work was performed at the two-digit level of Statistics Canada's Standard Industrial Classification(SIC) system. The model consisted of 30 sectors (Table 1.1), 5 primary sectors, 19 secondary sectors and 6 tertiary sectors, which included 2 sectors covering municipal water use. Three of the tertiary sectors (construction; transportation, storage and communication; and "other") contained no water use, and were included merely to preserve the comprehensiveness of the model.

The rural domestic water use sector, although accounted for in the 1981 water use totals, were not forecasted. Rural domestic usage, the use of water in rural residences, accounted for less than 1% of total Canadian water withdrawals (see Chapter 4). It did not correspond, for forecasting purposes to any of the input-output sectors. An attempt was made to forecast it as part of the agriculture sector, but this was not successful since

WATER USE SECTORS

TABLE 1.1

Industry Number	Description
1	Agriculture
2	Forestry, Fishing, Hunting and Trapping
3	Metallic Minerals
4	Mineral Fuels
5	Non-metallic Minerals
6	Food and Beverages
7	Tobacco Products
8	Rubber and Plastics
9	Leather Products
10	Textiles, Knitting Mills and Clothing
11	Wood Products
12	Furniture and Fixtures
13	Paper and Allied Products
14	Printing and Publishing
15	Primary Metals, except Iron and Steel
16	Iron and Steel
17	Metal Fabricating
18	Machinery
19	Transportation Equipment
20	Electrical Products
21	Non-metallic Mineral Products
22	Petroleum and Coal Products
23	Chemicals and Chemical Products
24	Miscellaneous Manufacturing
25	Construction
26	Transportation, Communication and Storage
27	Electric Power
28	Gas and Other Utilities
29	Wholesale and Retail Trade
30	Other (i.e. Finance, Insurance, Real Estate, etc.)

agricultural water use is tending to increase, while farm population is falling. Neither did the sector fit logically into the population-related "industries" of the inpt-output table. Thus, the rural domestic sector was not included in the forecasts contained in this report.

In the main report, water use forecasts will be reported for five aggregated sectors: agriculture, mineral extraction, manufacturing, power generation and municipal uses. Detailed data on each of the 30 sectors are available upon request.

1.3.6. Primary Research Emphasis

The primary variables considered in this research were economic activity levels, the state of production technology and various types of water use practices. This selection was made because the author recently found, in another piece of research (Tate, 1984) that these three factors working together could account for all of the change in water use through time. The economic factor was responsible for large increases in inter-period water use. The increases were offset by trends in production technology, which tended to lower water use. The water use coefficient factor had a small and variable (in sign terms) effect on total water use. Choice of approaches to the research was based upon an extensive methodological review carried out previously by the author (Tate, 1984a, Chapter 3).

The approach used for the national:regional analysis was based on a structural model of the five regional economies, augmented to include the analysis of water uses. This 30-sector model produced consistent estimates of water use for each region under a variety of

assumed future scenarios. Economic activity levels were reflected in these regional models as final demands for goods and services. Production technology was assumed to be captured by the input-output inverse matrices used. Water use practices were modelled by means of water use coefficients. The complete structural model is described in Chapter 2.

1.3.7. Coping with Future Uncertainty

The hallmark of futures studies is a large degree of uncertainty, and that is certainly the case in this piece of research. Uncertainty arises in virually every facet of this work. Economic forecasting, beyond a one or two year period enters the realm of speculation. Forecasting technological and structural change is even more speculative. Water use practices by industrial plants is the product of many unpredictable decisions. These somewhat gloomy and negative statements are made, not to express the imprecise nature of the forecasting task, but to place into perspective the methodology and outcome of this study.

It follows from the assumption of uncertainty that unitary forecasts of future water use are not very useful. The chance of being accurate on a forecast of water use 30 years hence are virtually zero. In any event, one predicted value for the future is much less useful for planning and management purposes than a knowledge of a range of possibilities and a prediction of how water use will react to changes in the underlying variables. The latter two tasks are the real challenge of the research.

The "alternative futures" approach has been used here to offset partially the uncertainty factor. The approach, which was formalized by the U.S. National Water Commission (1973), concentrates upon developing a range of values for each major variable underlying water use, and grouping these values into logical and consistent views of the future. Examination is then made of the impact of each future view or "scenario" on water use in each sector. The alternative futures approach as used in this research is documented in detail in Chapter 3.

1.3.8. Issues of Water Demand Management and Water Pricing

In Canada, as in much of the rest of the world, water has traditionally been considered a "free" good. Approaches for water use forecasting have tended to view the future as a series of "requirements", which had to be met. However, many studies (e.g. Grima, 1972; Howe, 1968; de Rooy, 1972, Kindler and Russell, 1984) have demonstrated that water use, in most activities and beyond certain minimal amounts, displays a "negative price elasticity", such that an increase in water price leads to a decrease in demand. This type of behavioral finding suggests that the level of water use can be manipulated, not only through pricing, but also through a variety of "demand management" measures. There are few Canadian studies in this area, despite the fact that demand management may offer many cost savings for water resource development in the future. Thus, while definitive answers are not possible as to the impact of, say, price on water use, some attempt will be made here to provide some indications of these impacts.

1.3.9 The Forecasts in Perspective

A note of interpretive caution is added at the end of this chapter. It is often true that an audience unfamiliar with the problems of forecasting will take the output of a study such as this as the true shape of the future. This note is intended to dispel such a notion. The forecasts contained here are hampered in at least two major ways. First, the problems of uncertainty have been described. Second, the methodology used, while soundly based and the best one possible given the circumstances, it is quite far removed from that of an ideal study. Thus, the interpretation given to these results is related more to the reaction of water use to a given series of conditions than as a series of "requirements" to be met. In chapter 5, some discussion is given of an alternative approach to water use studies which would be possible given a longer study period. This approach would supplement and improve the results obtained in the main part of the paper.

CHAPTER 2

METHODOLOGICAL OVERVIEW

This chapter provides an overview of the methodology used in compiling the water use forecasts produced during this project. The principal model employed is outlined at the level of detail considered necessary in this report, although many technical points have been omitted; these may be found in the references contained here. The methodology for the simulation modelling exercise is outlined separately in Chater five.

2.1 An Overview and Comparison of Methodologies

This section comprises an overview of six distinct types of methodologies which have been used in the past for water use and demand forecasting. These methodologies are dealt with summarily here; more detail may be found in Whittington (1978), Kindler and Russell (1984) and Tate (1984a)

2.1.1 The Coefficients Approach

Many water use studies (e.g. Cass-Beggs, 1961; Canada, 1972) have been based upon the coefficients approach, which is the simplest approach to water use forecasting. A relationship is assumed between water use and one (independent) variable, such as time, employment, or level of output. A coefficient of water use per unit of the independent variable is calculated or assumed from other sources. This coefficient is taken as constant over the forecasting time horizon, and is multiplied by forecasts of the independent variable to produce water use forecasts. This "methodology" is cheap to implement in time and cost terms, but is normally unreliable in the absence of any theoretical basis

for linking water use to one independent variable and for projecting this relationsip into the future.

2.1.2 The Regression Approach

This type of methodology is based on multiple regression analysis. Relationships are hypothesized between water use and a number of independent variables, such as output levels and types, recirculation rates, water price, etc. Statistical data are then collected on the hypothesized relationships, and used to calibrate the regression equation. Future values of the exogenously projected independent variables are then used in conjuction with the regression equation to project water use. This type of methodology is a substantial improvement over the coefficient approach, being based upon testable hypotheses and a firm statistical foundation. Its wide application in studies such as the present one is limited, however, because it must be tailored to fairly homogeneous groupings of industrial or municipal water use (see Rees, 1969; Grima, 1972). While this presents no limitation if the requisite studies exist, it is a severe limitation in resource terms if they do not, as is the case in Canada. For these and other reasons summarized in Table 2.1, the regression approach was rejected as the basis of this project.

2.1.3 The Demand Management Approach

As used in this paper, the demand management approach to water use forecasting refers to studies in which a price:quantity relationship is used to define an equilibrium between water use and water supply. Water supply shortages under this approach are

TABLE [illegible]. COMPARISON OF WATER USE FORECASTING METHODOLOGIES

Methodology	Data Avail-ability	Alterna-tive Futures	Techno-logical Change	Economic Interrel-ationships	Spatial Resolution	Overall Cost	Theoretical Basis
	Criteria for Comparison						
Coefficients	High	Medium	Low	Low	High	Low	Low
Regression	Low	Medium	Low	Low	Low	High	Medium
Demand Management	Low	Medium	Low	Low	Low	High	High
Process Modelling	Low	High	High	Low	Low	Very High	High
Structural Modelling	High	High	High	High	Low	Low	Medium
Simulation Modelling	Medium	High	High	High	High	High	Medium

Criteria Descriptions

Data Availability - Ease with which data can be collected. High is best.
Alternative Futures - Ability to consider a wide variety of alternative futures. High is best.
Technological Change - Ability to incorporate technological change. High is best.
Economic Interrelationships - Incorporation in the model of relationships between economic sectors. High is best.
Spatial Resolution - Ability to consider river basin and subbasin detail. High is best.
Overall Cost - The total required expenditure in terms of money and person-years. Low is best.
Theoretical Basis - The degree to which the methodology is based in theoretical principles. High is best.

met through a combination of water price rises (to decrease demand) and supply augmentation where this is shown to be the most economically efficient approach. In Canada, few studies have been made which could be classified under the demand management approach (e.g. Grima, 1972; Canada, 1975; Sewell and Roueche, 1974), and thus the required statistical basis for using it generally is not available. The resources were unavailable to carry out a full demand management approach during the present project, although the topic of demand management was explored in one of the scenarios developed as the basis of the water use forecasts (see Chapter three).

2.1.4. The Process Modelling Approach

In contrast to the methodologies outlined to this point, which treat the actual operation of the water using process as a "black box", the process modelling approach attempts to model water use as an integral part of the production process under study. Examples of this approach may be found in Russell, 1973), Russell and Vaughn (1976) and Kindler and Russell (1984). The forecasts produced are of high quality, since water use and the productive process are closely linked, and subjects such as technological change can be addressed specifically. The limitation of the approach in a broad regional study is that each operation (e.g. one industrial plant) must be dealt with individually, imposing very high time, labour and budgetary costs. The approach was not used here.

2.1.5 The Structural Modelling Approach

Structural modelling of water uses is founded upon the use of input-output models (see Richardson, 1972; Myernick, 1965) to forecast water use. The approach incorporates a comprehensive view of the economic structure under consideration, and is relatively straight-forward to implement. It is the basis of much of the research in this project and will be described more fully in the following section.

2.1.6 The Simulation Modelling Approach

This approach relies upon relating the variables underlying water use in a logical and consistent fashion into a computerized model. This model, once calibrated, can then be used to produce water use forecasts for a variety of future conditions. Simulation modelling is outlined in more detail in Chapter 5.

2.2 Structural Modelling of National and Regional Water Use

The model used in examining future water use in Canada and its regions is based upon input-output analysis, as indicated in section 2.1.5. Input-output analysis is an econometric technique which examines the flows of goods and services in an economy, both between the industrial production sectors themselves and from those sectors to the points of final consumption, or final demand. The analysis is based upon an input-output transactions table, such as the one shown in Figure 2.1. The X factors refer to interindustry flows. For example, x_{ij} refers to the flow of product from industry i to industry j. C, I, G and E refer to the final demand sectors, namely consumption by households, private investment, government purchases and exports,

Figure 2.1 A Simplified Input-Output Transactions Table

From	To	Purchasing Sectors $1 \ldots\ldots i \ldots\ldots n$	Final Demand Sectors: Households	Private Investment	Government	Exports	Total Gross Outlays
Producing Sectors	1	$X_{11} \ldots X_{1i} \ldots X_{1n}$	C_1	I_1	G_1	E_1	X_1
	.	. . .	.	.	.	.	.
	.	. . .	.	.	.	.	.
	.	. . .	.	.	.	.	.
	i	$X_{i1} \ldots X_{ij} \ldots X_{in}$	C_i	I_i	G_i	E_i	X_i
	.	. . .	.	.	.	.	.
	.	. . .	.	.	.	.	.
	.	. . .	.	.	.	.	.
	n	$X_{n1} \ldots X_{nj} \ldots X_{nn}$	C_n	I_n	G_n	E_n	X_n
Labour		$L_1 \ldots L_j \ldots L_n$	L_C	L_I	L_G	L_E	L
Other Value Added		$V_1 \ldots V_j \ldots V_n$	V_C	V_I	V_G	V_E	V
Total Gross Outlay		$X_1 \ldots X_j \ldots X_n$	C	I	G	E	X

Source: Richardson (1972, p. 19).

respectively. These are the final points of consumption for the goods and services produced. L and V refer to input from primary sources external to the production system, in this case labour and other value added repectively. Reading across the rows of the table, one can determine the distribution of the product of each industry, to itself, to other producers and to the various final demand sectors. Conversely, reading down the table, one sees from where each industry draws its inputs. As portrayed in the bottom row and right-most column, total inputs to each industry balance total outlays.

Input-output tables can be used to formulate accounts comparable to the system of Keynesian national accounts used traditionally in government descriptions of production in the economy (e.g. gross national product). However, the normal use of an input-output table is as the basis for a model linking changes in industrial production to changes in final demand, and for examining the processes of structural and technological change. Although many forms of input-output models exist, the one described below is probably the most basic, having a "square", or industry-by-industry format and pertaining to a single region or a nation as a whole.

For industry-by-industry models, the set of producing sectors is identical to the set of purchasing sectors. The relationships between total output, intermediate output and final demand for any industry can be stated as:

$$x_i = \sum_{j=1}^{n} x_{ij} + y_i \qquad \text{(Eq. 2.1)}$$

where: x = the sum of sales from industry i to industry j;

x = the total value of sales of industry i;

y = the sum of the final demands for the products of industry i.

Assuming that industry j's purchases from industry i are stable in terms of industry i's output, equation 2.1 may be re-written as;

$$x_i - a_{i1} x_1 - a_{i2} x_2 - \ldots - a_{ij} x_j = y_i \qquad \text{(Eq. 2.2)}$$

where: a = the direct input requirements for industry i's product per unit of output in industry j.

In equation 2.2, the a_{ij}'s are termed "direct input coefficients" since they denote how much of industry i's output must be purchased by each industry per unit of output.

The objective of input-output analysis is to estimate total output in each industry, given the level of final demand for each industry's product. This task involves tracing not only the direct first round output required to meet these final demands, but also the secondary production resulting as the initial demands filter through the productive system. The methodology for accomplishing this is outlined by Miernyck (1965) and is summarized mathematically here. In terms of matrix algebra:

$$x - Ax = y \qquad \text{(Eq. 2.3)}$$

where: x = a column vector of gross output;

y = a column vector of final demands;

A = an (n x n) matrix of direct input coefficients.

Using an identity matrix, equation can be rewritten:

$$(I - A).x = y \qquad \text{(Eq. 2.4)}$$

where: I = an (n x n) identity matrix.

Since the level of gross output in each industry is the variable being solved for, the system can be rewritten as:

$$x = (I - A)^{-1}.y \qquad \text{(Eq. 2.5)}$$

where: $(I - A)^{-1}$ = the inverse of $(I - A)^{-1}$, derived through the process of matrix inversion.

The elements of the inverse matrix quantify the direct plus indirect requirement of industry i per unit of final demand for the outputs of industry j. Equation 2.5 defines a linear transformation of final demands in an economy into industrial outputs.

The assumptions behind this model have been discussed by Richardson (1972), Davis (1968) and Victor (1972), and reference should be made to these sources for more detail. Very quickly, two major assumptions allow the model to operate. First, outputs by industries are considered to be homogeneous, such that one industry produces a uniform product or an "average bundle" of products. This assumption has received strong criticism (see Victor, 1972), and has led several countries, including Canada, to adopt a "commodity-by-industry" approach to input-output modelling. The more conventional "industry-by-industry" approach was used here because of the infeasibility of dividing water use

data into commodity groupings. Second, the technological coefficients (a_{ij}) are assumed constant in many input-output analysis exercises; this assumption has proven false in many cases because of structural and technological change. It has been overcome in one of the scenarios examined here by alterations to the inverse matrices in accordance with past trends.

In a study of the California water industry, Lofting and McGauhey (1963) augmented the basic input-output model to include water use considerations. Their augmentation consisted of inserting a matrix of water use coefficients into equation 2.5, as follows:

$$w = (I - A)^{-1} . W. y \qquad \text{(Eq. 2.6)}$$

where: w = a vector of total water uses for each industry in the system

W = an (n x n) matrix of water use coefficients in which the coefficients (in terms of water use per million dollars of output) form the elements of the matrix's principal diagonal, and all off-diagonal elements are zeroes.

This model formed the basis of the national and regional water use forecasts developed in the present research.

The model specified in equation 2.6 contains the three factors suggested in Chapter 1 to underlie water use in the various economic sectors. Economic activity and its growth are captured by the final demand factor (y). The elements of the

inverse matrix $(I - A)^{-1}$ denote the state of production technology. Water use practices (e.g. trends in recirculation) are captured by the elements of the water use coefficients matrix (W).

2.3 Making The Structural Model Operational

This section contains an outline of the procedures and data used to make the structural model operational. Each of the model's variables are dealt with separately here; the ways in which they were combined to produce the forecasts are dealt with in Chapter 3.

2.3.1 Economic Activity

Economic activity levels were dealt with in the model through the final demand variable. The regional models used were based on 1974, the latest year for which complete input-output data are available. The 1974 final demand data were projected to the 1981 base year of this study by using growth rates experienced between the two years. With the 1981 final demand calculated, the original 1974 tables were used in conjunction with the model described in equation 2.5 to calculate the gross outputs in each of the 30 industries. For industry 28, Gas and Other Utilities, and industry 29, Wholesale and Retail Trade, which are substantially related to population, population growth rates were used to calculate the 1981 final demand and output levels. (It is acknowledged here that interregional structural models could isolate and thereby model the effects of interprovincial trade. The interregional modelling approach was not used here, however, due to time constraints, and thus regional exports and imports

are considered here to be part of the regional final demand vectors.)

Forecasting future growth rates in industry and the population is a complex undertaking done normally by specialist forecasting agencies using sophisticated econometric models. In addition, forecasts are rarely performed over a 30-year horizon. For this project, extensive work was done to obtain a consistent set of growth rates for the 30 industry sectors, some of it working from historical statistics published by Statistics Canada, some of it searching through past work by the author and some of it examining forecasts produced by private forecasting agencies. In the end, it was decided to use one of the latter sources, namely the forecasts recently produced by Informetrica (Informetrica, 1984), and available to Environment Canada by subscription.

From the Informetrica forecasts, projected real domestic product (RDP) and labour force series were compiled for 1983, 1991, 2000 and 2005, and for each industrial group except the two groups related more closely to population. For 1981, 2001 and 2011, years required by this study but not available from the Informetrica data, extrapolation and interpolation procedures were used. Growth rates for the 1981-1991, 1991-2001, and 2001-2011 periods were then calculated for both RDP and labour force series. In general the growth rates for the former were greater than those for the latter, due to capital substitution effects. Accordingly, a low set of growth rates was based upon the labour force series and a high set upon the RDP series. A

medium set of rates was constructed from an average of the high and low rates.

2.3.2. Production Technology

The modelling of trends in technological change is an exceedingly difficult undertaking, largely because there is much controversy about the variables which lead industries to make modifications to their production processes. Trends are the product of thousands of individual decisions, and few summary statistics are available about the outcome of these decisions.

In this research, it was assumed that the coefficients of an inverse matrix resulting from input-output models reflect the state of production technology for the time period covered by the input-output table. Thus, a time trend on each coefficients constitutes a production technology time trend. A set of trends consisting of trends for each coefficient can be calculated by linear regression techniques, making appropriate adjustments for autocorrelation. The statistically significant trends can then be projected, while those which are not significant can remain constant. This procedure was used for forecasting production technology.

All of the regression work was performed at the national level, for which a 20-year time series of annual input-output tables was available. While it would have been more desirable to work with a time series of regional tables, these were unavailable. As a "second-best" alternative, the national trends were superimposed on the regional industrial sectors. To begin this part of the analysis, regression lines were computed

for each of the 900 coefficients of the 20 inverse matrices. For example, each industry is tied by the coefficients of the inverse to itself and to each of the other 29 industries. Thus, each industry forms one column of the inverse matrix, consisting of 30 coefficients. Each of the 30 coefficients in turn has been analyzed through time by means of the regression procedure outlined above. In those cases where the regression equation accounted for 50% or more of the total variance (i.e. $R^2 = 0.5$), the trend was considered significant. Where the industry being analyzed was significant in a region, the national trends were used to project the respective regional coefficients. Where the national equation was found insignificant, the regional coefficients were assumed to be constant. Using this procedure, adjusted inverse matrices were calculated for the years 1981, 1991, 2001 and 2011 for each of the five regions. These matrices were assumed to simulate the magnitude and direction of technological change over the forecasting time horizon.

2.3.3. Water Use Practices

As used in this paper, water use practices refer to the amount of intake, recirculation, gross water use, consumption and discharge which occurred in the industrial sectors covered by this study. Trends in water use practices, likewise, refer to trends observed or anticipated in these five parameters. Water use practices were quantified for use in the model by calculation coefficients of water use (i.e. by parameter) per million dollars of total industrial output for the year 1981. This set of water use coefficients formed the major means of quantifying water use

practices throughout the period of study. The recent federal and Alberta surveys of industrial water use (Canada, 1985) were used as the quantitative basis for the coefficients.

The set of 1981 coefficients were modified demonstrate (1) the potential impact of raising the price of water in the various sectors, and (2) the effects of other conservation measures. The point must be made here that the results of this water conservation analysis are considered theoretical and indicative in nature rather than certain projections of what would happen under a water management philosophy which tries to control water use with pricing and other conservation techniques.

Several articles referred to in Chapter 1 have shown that water demand, like demand for the vast majority of goods and services, behaves in a "conventional" economic fashion, such that when its price rises, the quantity demanded falls. In Canada, water pricing data are not available on a consistent basis across the country in such a manner that regional water demand curves can be constructed. The best data available are those collected during the 1981 federal and Alberta surveys of industrial water use referred to earlier. On these surveys, the cost of water at a plant was taken as the sum of intake cost, intake treatment cost, recirculation cost and effluent treatment cost. By adding these cost components together and dividing by the amount of intake, the average cost of water for each industry can be calculated. This amount, which has been used in the past as a proxy for water price (e.g. see de Rooy, 1972, 1974), can be taken as the price of water to industries, which is felt in the

absence of a commodity price for water. In other words, it is assumed here that the industries face a zero or minimal commodity price for their water. This method of estimating water cost is biased somewhat downward since there is no allowance made for the capital cost of water conveyancing facilities in plants.

Another important piece of information required for the pricing analysis is a set of price elasticities of demand for water in the various industries. Price elasticity of demand indicates the percentage change in the quantity of water demanded for a given percentage change in water price. On a normal downward sloping demand curve, price elasticity changes along the curve. In this paper, the elasticity figures assumed are taken to be average elasticities, and are thus constant through the range of price. Estimates of price elasticities of water demand, which were unavailable in many cases for Canada, were taken from various secondary sources (Hanke, 1978; Grima, 1972; Leone, 1975; Boland et al., 1984). Where no data were available, judgemental estimates were made for related industrial groups for which data were available. By assuming average demand elasticities for each industrial group, an analysis was performed of the impact of water price rises on the quantity of water demanded. The price increase assumed was 10% by 1991, 25% by 2001 and 35% by 2011.

The water intake coefficients calculated from survey data show how much water is used by industry in the absence of a commodity price for water. It is suggested that the pricing analysis outlined above indicates how the coefficients will alter as increasing prices are charged. In other words, with the

elasticity data available or assumed, it was possible to estimate the response of water intake in the various groups to given percentage increases in the average cost (i.e. price) of water. Gross water use and consumptive use coefficients were calculated for each industrial group using the use rates and consumption rates respectively. This type of analysis was the basis for one of the scenario analyses outlined in Chapter three.

In addition to price change impacts, there are many additional water conservation measures possible. To allow for these additional impacts the effects of the hypothesized water pricing arrangements were accentuated by an arbitrary 50%. As noted earlier, this analysis is quite hypothetical, but is felt, nevertheless, to be feasible should serious attempts be made to apply water conservation incentives in managing Canada's water resources.

CHAPTER 3

FORECASTING AND THE ROLE OF ALTERNATIVE FUTURES

The process of forecasting water uses is highly dependent upon the underlying view taken of the future. It is this view which governs the mix of industries used for forecasting, their technological conditions, the level of population, energy and water use practices, and many other factors. As noted in Chapter one, each of these factors by itself is subject to considerable uncertainty, and when the factors are combined the resulting uncertainty may be compounded.

As noted in Chapter one, the "alternative futures" approach has been used in preparing the forecasts for this paper. This type of approach has been used in many forecasting exercises, and was specified in detail by the U.S. National Water Commission (1976). Obviously, not all of the permutations and combinations of variables can be examined. However, it is possible to try to select a number of typical combinations of future situations. (Throughout the remainder of this paper, these combinations will be referred to as "scenarios".) In this way, an attempt can be made to place "a fence around the ballpark of future water use."

In this chapter, the first section discusses some of the general considerations made in designing the scenarios. The second section defines in operational terms the five scenarios finally selected for analysis.

3.1 General Considerations

In this project, as noted in Chapter one, an analytical approach to the future has been taken. Several types of factors

can be approached analytically, and are built into the five scenarios. Population was allowed to assume three alternative projections, based upon the latest Statistics Canada work (Canada, 1982). Various future mixes of primary, secondary and tertiary industrial activities resulted from using high, medium and low alternative growth rates. Energy use assumptions are implicit in these projections. Technological change was allowed in one of the scenarios according to the methodology of Chapter two. Finally environmental policy as it affects water use was varied in one scenario to simulate the effects of a conservationist policy stance.

The principal task in scenario design is to translate these various assumptions about the future into terms which can be dealt with by the structural and simulation models used as the basis for the analysis. This translation task is described in section 3.2. Before turning to that description, it is necessary to define some of the factors which have been assumed constant.

In any forecasting exercise, certain factors must be held constant in order that a common background for the scenarios may be established. In general, the more time available for the analysis, the fewer the number of constancies required. In this exercise, time limitations were quite severe, with the result that even some of the analytically tractible variables were assumed to be common to all scenarios. The forecasts assume an absence of global armed conflict. This was necessary because one has no means of foretelling what kind of devastation or socio-economic conditions would arise from such conflict.

Lifestyles are assumed not to alter radically with regard to their water needs. This allows for lifestyle changes as they may occur, but assumes that water demands caused by new lifstyles will not be radically different. Current institutional and administrative arrangements have been assumed to continue throughout the forecasting time horizon. The one exception here will be an assumed rise in water price, and the aggregate results of a concerted water conservation effort in scenario three. Urbanization trends, implicit in the population projection, have not been considered explicitly in the forecasts. Finally, it was assumed that no new industrial classifications would originate during the forecasting period.

3.2. Five Views of the Future

As specified in the structural model, three sets of growth rates (low, medium and high), two types of technological conditions (stable and changing) and two sets of water use coefficients (stable and price-altered) were used in preparing the forecasts for this project. Thus twelve possible scenarios could have been prepared by altering just the major variables. However, within each major variable, assumptions could have varied by industrial sector, thereby increasing enormously the number of alternative future outlooks.

The author has been forced to compromise between designing scenarios which could be described in detail, and presented as feasible views of the future, and those which would describe the sensitivity of the model to broad changes in assumptions about each major variable. It was decided to emphasize the latter task.

Thus, the scenarios reported below have been designed to indicate the sensitivity of the structural model to changes in each of its major variables. The reader may then combine the variables as he himself sees fit and thus examine other futures. It should be noted that none of these scenarios has been designated "most likely".

3.2.1 Scenario 1 - A Reference Case

The reference scenario was constructed by holding all factors constant except the economic growth rate, and is, therefore, essentially an extrapolation of past trends. No changes in production technology was incorporated and the water use coefficients were held at their 1981 levels. A medium level of population growth was also used. The scenario assumes no severe energy shocks such as those experienced during the 1970's. It has been kept as simple as possible to serve as a reference point for the other scenarios. For this reason technological change has not been incorporated, even though it is on-going.

This scenario is a "business as usual" view of the future, with no significant shocks to the socio-economic system. Water is managed as it is currently, with major capital works occuring as required, under Canada's current supply management orientation to water development (Tate, 1984b). No requirements are foreseen here for major regional water transfers.

3.2.2 Scenario 2 - A Conservationist Scenario

In the water management field, increasing attention is being paid to policies for water conservation, and the potentialities of water demand management in Canada (Mitchell, 1984). One

major instrument offered for demand management is an increase in water price, accompanied by a major incentive system to implement other non-price related possibilities for decreasing water use. The scenario assumed a medium rate of economic growth, a constant production technology and the set of price-altered water use coefficients specified in Chapter 2.

3.2.3 Scenario 3 - The Effects of Technological Change

This scenario was designed to isolate the effects of production technology changes on water use in the five regions. It is difficult to describe the exact characteristics of this scenario, for changes on growth and water use practices would likely accompany it. Emphasis would be placed on technological change, so as to achieve at least the rates of change experienced in the past. Operationally in the model, the medium set of growth rates, the contstant 1981 water use coefficients and the technology-altered set of inverse matrices were used in preparing this scenario.

3.2.4 Scenario 4 - A Recession Scenario

Scenario 4 was based upon a prolonged period of slow economic growth throughout the country. Under such an assumption, recessionary conditions would ensue, as reflected in the scenario by the use of low growth rates. No money would be available to alter either the state of production technology or the water use practices. Thus the latter two variables were held at their 1981 levels.

Under this scenario, unemployment might reach the 16% - 20% levels. No attention at all could be afforded to environmental

programs, and few water conservation efforts would be made. Increasing forced leisure time would generate the need for more recreational resources.

3.2.5 Scenario 5 - High Economic Growth

In scenario five, emphasis was placed upon maximizing economic efficiency and achieving a high rate of economic growth. Partially this will be achieved through exploiting to the full the raw material wealth of the country and developing its primary industry base. Rapid development was also foreseen in the manufacturing sectors, based upon acclerating the role of these industries (i.e. industries 1 to 5 in the model). Thus the primary and the secondary sectors assumed high rates of growth. To support this growth, high growth rates were also assumed in the tertiary sectors. Techological change and water use practices were held constant in order to isolate the effects of the high growth rate.

Under this scenario, economic growth was the primary public objective. Little or no attention was assumed in environmental programs and water conservation. Water use practices were held at the 1981 levels. Unemployment would probably be below the rates experienced under the medium scenario.

The operational components of the six scenarios are summarized in Table 3.1.

Table 3.1 A Summary of the Scenarios Used in Forecasting

Scenario Number and Name	Principal Components of the Structural Model		
	Economic Growth	Production Technology	Water Use Practices
1. Reference	Medium	Constant	Constant
2. Conservation	Medium	Constant	Altered
3. Technological Change	Medium	Altered	Constant
4. Recession	Low	Constant	Constant
5. High Growth	High	Constant	Constant

CHAPTER 4

CURRENT AND PROJECTED CANADIAN WITHDRAWAL WATER USES

This chapter is devoted to a discussion of the study results. The first section outlines the major observations deriving from the forecasting exercise. More detailed data have been placed in the Appendix. The second section deals with limitations which must be placed upon these results.

4.1 Results of the Study

4.1.1. Water Use in 1981

In 1981, just over 37 500 million cubic metres (MCM) of water were withdrawn from Canadian water sources (Table 4.1). About

TABLE 4.1 TOTAL WATER USE BY WATER USE PARAMETER CANADA AND REGIONS, 1981 (MCM)

Region	Water Intake	Recirculation *	Gross Water Use	Consumption	Discharge**
Atlantic	2884	965	3849	139	2745
Quebec	4252	3094	7346	435	3817
Ontario	21230	4122	25352	589	20641
Prairie	5363	4675	10038	2256	3107
B.C.	3789	3062	6851	487	3302
Canada	37518	15918	53436	3906	33612

* Imputed figure. Recirculation = gross water use - water intake.
** Imputed figure. Discharge = water intake - consumption.
Source: Appendix tables

56% of this amount was withdrawn by users in Ontario, mostly from the Great Lakes. Of the 21 230 MCM withdrawn in Ontario, about 70% was accounted for by use in thermal cooling at power plants. The Prairie region was the next highest with respect to water withdrawal, with a large amount of this water being used in

irrigation. The other three regions followed as indicated in Table 4.1.

Gross water use followed essentially the same pattern, totalling 53 436 MCM. In other words, recirculation practices allowed the available water supplies to be "stretched" some 1.4 times. The aggregate use rate (i.e. gross water use divided by water intake) was about 1.4, being lowest in Ontario (1.2) and highest in the Prairies (1.9). In all, almost 16 000 MCM of water were recirculated throughout Canada in 1981.

Water consumption totalled 3 906 MCM in 1981, just over 10% on total intake. The lion's share of this amount was accounted for by agricultural (mainly irrigation) use in the Prairie region, with 1 892 MCM (see Appendix tables). The consumption rate (i.e. water consumed divided by water intake) in this region was 0.4, very high in comparison with the other four regions. The lowest consumption rate (0.03) was experienced on Ontario, where none of the intake water at thermal power plants was recirculated. With a consumptive use of 3 906 MCM, discharge totalled 33 612 MCM in 1981.

Table 4.2 views the same data from the viewpoint of the major economic sectors included in the study. The largest proportion of water intake, over 51% of the total was attributable to thermal cooling at electric power plant, centred in Ontario, but also important in the Prairie and Atlantic regions. Recirculation was practiced principally in the mineral extraction and manufacturing

TABLE 4.2 TOTAL WATER USE BY WATER USE PARAMETER AND INDUSTRY, CANADA, 1981

(MCM)

Region	Water Intake	Recirculation *	Gross Water Use	Consumption	Discharge**
Agriculture	3125	0	3125	2412	713
Mineral Ext.	648	2792	3440	179	469
Manufacturing	10201	11258	21459	507	9694
Power Generation	19281	1868	21149	168	19113
Municipal	4263	0	4263	640	3623
Canada	37518	15918	53436	3906	33612

* Imputed figure. Recirculation = gross water use - water intake.
** Imputed figure. Discharge = water intake - consumption.
Source: Appendix tables

industries, with use rates of 5.3 and 2.1 respectively. A small amount of water recycling also occurred in the power sector, at two plants in Alberta. Recirculation occured in neither the agriculture nor the municipal sectors.

Consumptive use was concentrated in the agriculture sector, focussing upon irrigation in the Prairie region. Due to this activity the consumption rate for agriculture was 0.77, greatly above the average for all sectors of 0.12. This rate was also relatively high for mineral extraction, where significant quantities of water were used for deep-well injection for enhanced petroleum recovery.The consumption rate was lowest in the thermal power sector, at 0.008, and, as noted in Chapter 2, the same rate for the municipal sector was 0.15.

Water intake in the rural domestic sector, which has been included in neither Table 4.2 nor the subsequent forecasts, totalled 348 MCM for Canada in 1981. Recirculation and

consumption were 0 for this activity. The water withdrawal in this sector was distributed as follows:

Region	% of Total Intake
Atlantic	17
Quebec	24
Ontario	28
Prairies	20
B.C.	11

4.1.2 Projected Water Use, 1981-2011

This section presents the results of the forecasting exercise undertaken for this project, concentrating on the reference case scenario. The other four scenarios are presented as comparisons to the reference case. It is stressed again that the reference case is not portrayed here as a "most likely" projection, but rather as a relatively simple extrapolation of past trends performed as a baseline for the comparison of alternatives. None of the scenarios, in fact, are designated "most likely", although the author considers that future water use will probably fall within the bands defined by combining the scenarios.

Table 4.3 shows how total national and regional water use grow under the assumptions of the reference case scenario. The average annual growth rate for total Canadian water intake under this scenario will be about 2.3% per annum, for consumptive use about 2.1%. The difference between the two rates occurs because some of the smaller industrial groups have a water intake but no consumptive use. The Ontario and Prairie regions will, under the reference case scenario, experience growth rates slightly above average at about 2.4%, while Quebec, with a 2.0% rate, will be somewhat below average. The Prairie rate is a

TABLE 4.3 PROJECTED TOTAL WATER INTAKE AND TOTAL CONSUMPTION BY REGION AND YEAR, 1981-2011 - REFERENCE CASE (MCM)

a. Total Water Intake

Region	1981	1991	2001	2011
Atlantic	2884	3575	4449	5584
Quebec	4252	5192	6276	7629
Ontario	21230	26484	33640	42861
Prairie	5363	7019	8832	11172
B.C.	3789	4608	5700	7085
Canada	37518	46878	58897	74331

b. Total Consumptive Use

Region	1981	1991	2001	2011
Atlantic	139	169	209	244
Quebec	435	494	582	690
Ontario	589	726	888	1093
Prairie	2256	2924	3600	4443
B.C.	487	598	729	893
Canada	3906	4911	6008	7363

response to continued agricultural growth slightly higher than the national average, as the region continues to dominate the country's agricultural sector. Ontario's relatively high rate is explained by expanded thermal power production at above the national rate. Neither of these two major sectors are important in Quebec, which will continue its reliance on hydro electric power (not included in the forecasts) and its traditional and relatively old economic base of manufacturing. The growth rate of water use in B.C. will be slightly below the national average, while that in the Atlantic region will be closest to the average.

TABLE 4.4 WATER INTAKE PROJECTIONS BY SCENARIO, CANADA, 1981-2011

(MCM)

Year	Scenario Number 1	2	3	4	5
1981	37518	37518	37518	37518	37518
1991	46878	41848	50511	43641	50275
2001	58897	45589	67222	51599	67011
2011	74331	47738	90879	58719	84039

Source: Appendix tables.

The forecasts for total Canadian water intake are shown in Table 4.4. Scenario 3, the technological change scenario, shows the highest rate of growth over the 30-year forecast period, with an average annual rate of 3.0%, while the lowst rate of growth occurs in conjunction with scenario 2 (0.8%). Scenario 3, the technological change future, was somewhat surprising in its outcome. Previous work had shown that production technology trends, taken by themselves, during the 1966-1976 period tended to lower industrial water use during the decade (Tate, 1984a). Thus, with the growth rate held constant, one would have expected the technological change scenario to track below the reference case. It is unfortunate that more time was not available to confirm the results obtained from scenario 3. The methodology selected for projecting the coefficients of the inverse matrices should be examined in more detail With regard to scenario 2, the impact of the hypothetical emphasis on conservation mechanisms to lower water use is clear. Water intake under such a regime would be 65% of that experienced using the reference case assumptions.

Table 4.5 summarizes the forecasting results in the context of the reference case scenario. This table confirms that the lowest and highest water intakes are associated with scenarios 2 and 3 respectively.

TABLE 4.5 IMPACTS OF ALTERNATIVE ASSUMPTIONS ON THE REFERENCE CASE SCENARIO FOR WATER INTAKE, CANADA, 1981-2011 (%)

Year	Scenario Number 2	3	4	5
1991	-11	8	-7	7
2001	-23	14	-12	14
2011	-36	22	-21	13

National trends in consumptive water use for the five scenarios are given in Table 4.6. The patterns shown in this table are essential the same as those estalished for water intake, with the growth rates being slightly less than the corresponding ones for intake. The consumptive use growth rates,

TABLE 4.6 WATER CONSUMPTION PROJECTIONS BY SCENARIO, CANADA, 1981-2011 (MCM)

Year	Scenario 1	2	3	4	5
1981	3906	3906	3906	3906	3906
1991	4411	4292	4977	4441	5298
2001	6008	4212	6319	5141	6990
2011	7363	3882	8074	5721	9025

are slightly less than those for water intake, because some of the smaller water using industrial sectors experience no water consumption. Impacts of alternative projection assumptions on the reference case are shown in Table 4.7. The figures are essentially the same as those shown in table 4.5.

TABLE 4.7 IMPACTS OF ALTERATIVE ASSUMPTIONS ON THE REFERENCE CASE SCENARIO FOR WATER CONSUMPTION, 1981-2011 (%)

	Scenario Number 2	3	4	5
1991	-13	2	-8	8
2001	-29	5	-14	16
2011	-47	10	-22	18

Table 4.8 shows the same set of data taken across industry groups. The thermal power sector continues to dominate the water intake projections, while agriculture continues its dominance of consumptive use. The average annual growth rates cluster between 2% and 2.5%, with the lowest rate being 1.6% for municipal intake, and the highest being 3.3 for the mineral extraction sector. Under the reference scenario, total water intake grows to 74 331 MCM in 2011, an average annual increase of 2.3%; consumptive use to 7 363 MCM (2.1%)

The growth patterns of water intake and consumptive use for Canada as a whole are shown in Figure 4.1. Both the reference case and the other four scenarios are compared in the top half of this figure. By 2011, the end of the forecasting period, water intake will range between 47 738 MCM and 90 879 MCM. These represent increases of 0.8% and 3.0% per annum respectively. The

industrial composition, or structure, of the reference case for each forecast year for the reference case scenario is shown in the bottom half of Figure 4.1. This figure demonstrates graphically the dominance of thermal power with respect to water intake and of agriculture with respect to water consumption.

TABLE 4.8 PROJECTED TOTAL WATER INTAKE AND TOTAL CONSUMPTIVE USE, BY INDUSTRY AND YEAR, 1981-2011 - REFERENCE CASE

a. Total Water Intake

Industry	1981	1991	2001	2011
Agriculture	3125	3991	4851	5897
Mineral Ext.	648	912	1255	1733
Manufacturing	10201	12602	15954	20274
Power Generation	19281	24216	30906	39558
Municipal	4263	5157	5931	6869
Total	37518	46878	58897	74331

b. Total Consumptive Use

Industry	1981	1991	2001	2011
Agriculture	2412	3089	3756	4567
Mineral Ext.	179	237	320	433
Manufacturing	507	639	812	1038
Power Generation	168	209	269	349
Municipal	640	737	851	976
Total	3906	4911	6008	7363

The forecasting results for each of the five regions are shown in Figure 4.2 through 4.6, supported by the tables in the Appendix. The regional forecasts are broken down into their component river basins also in the Appendix. Figures 4.7 to 4.13 highlight withdrawal and consumptive use amongst the basins of each region. Since the model used for forecasting was

FIGURE 4.1 - WATER USE PROJECTIONS, CANADA, 1981 - 2011

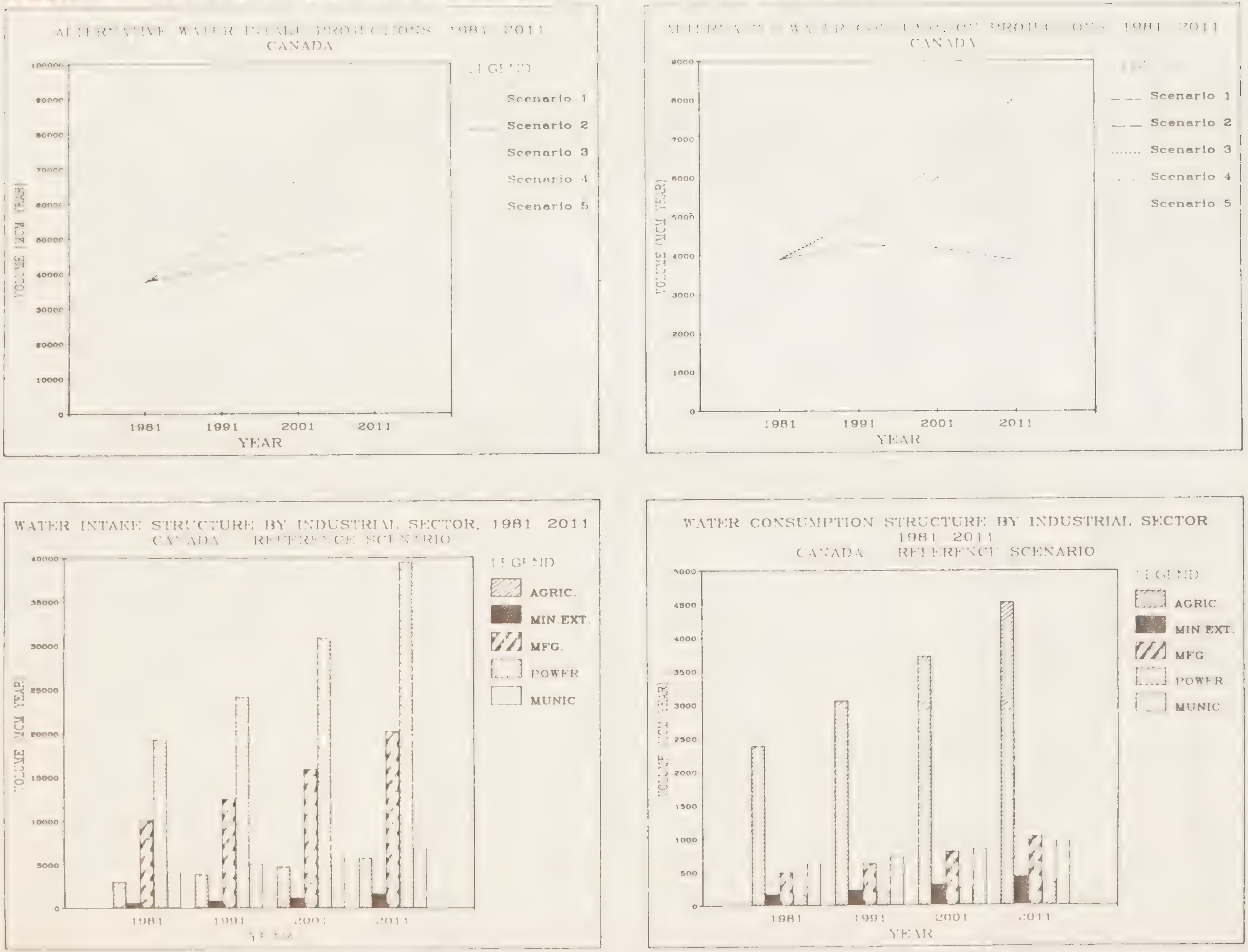


FIGURE 4.2 - WATER USE PROJECTIONS, ATLANTIC REGION, 1981 - 2011

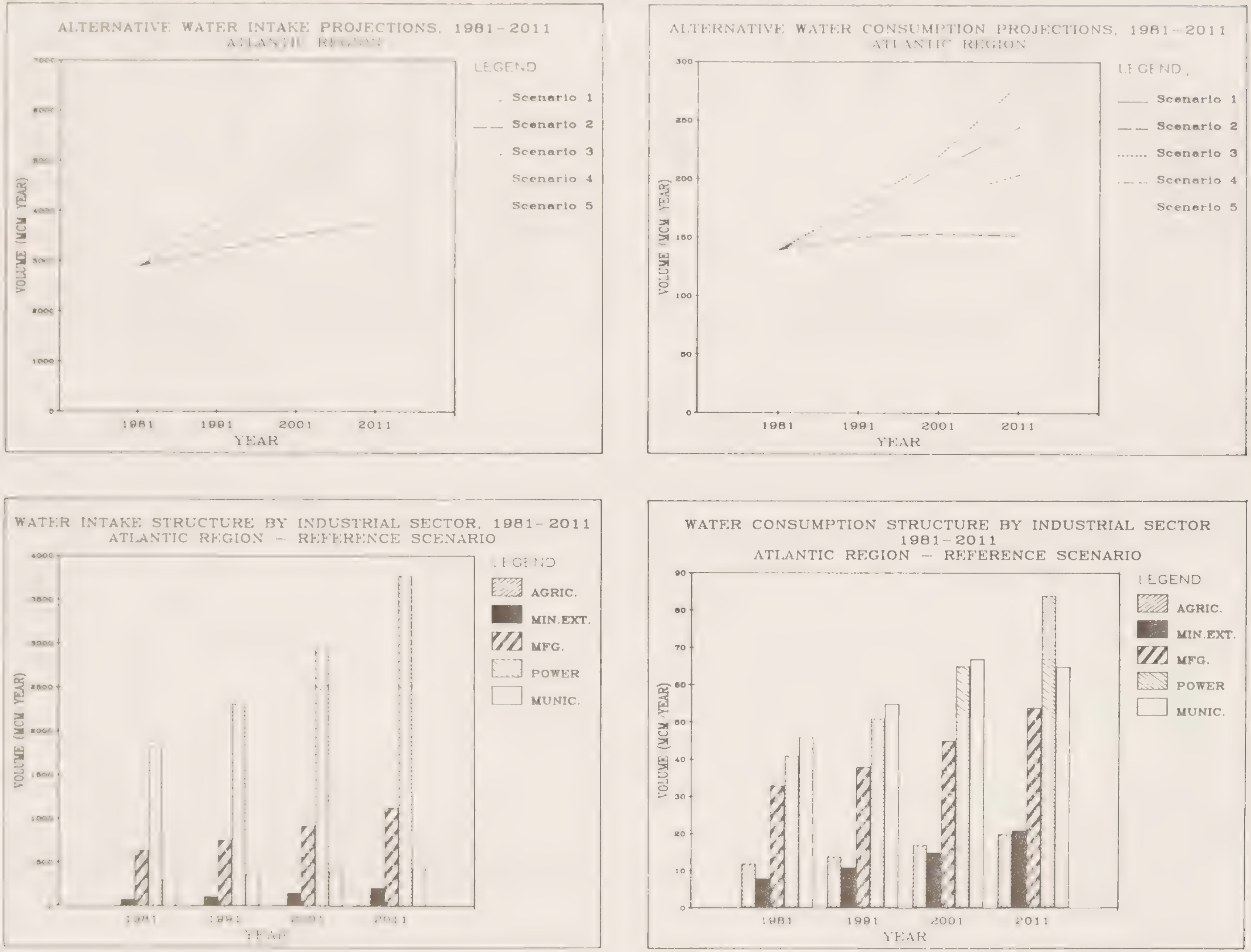


FIGURE 4.3 - WATER USE PROJECTIONS, QUEBEC REGION, 1981 - 2011

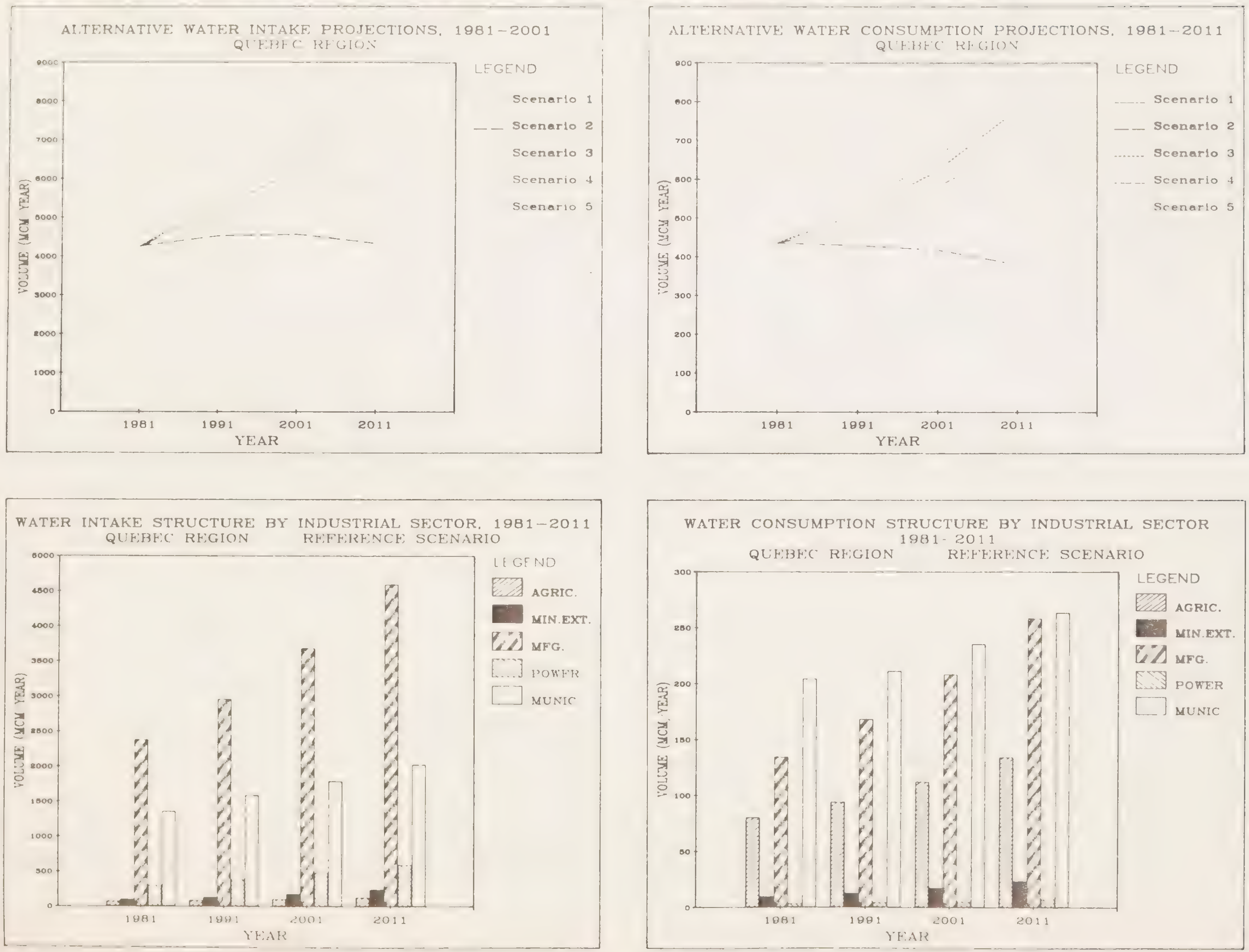


FIGURE 4.4 - WATER USE PROJECTIONS, ONTARIO REGION, 1981 - 2011

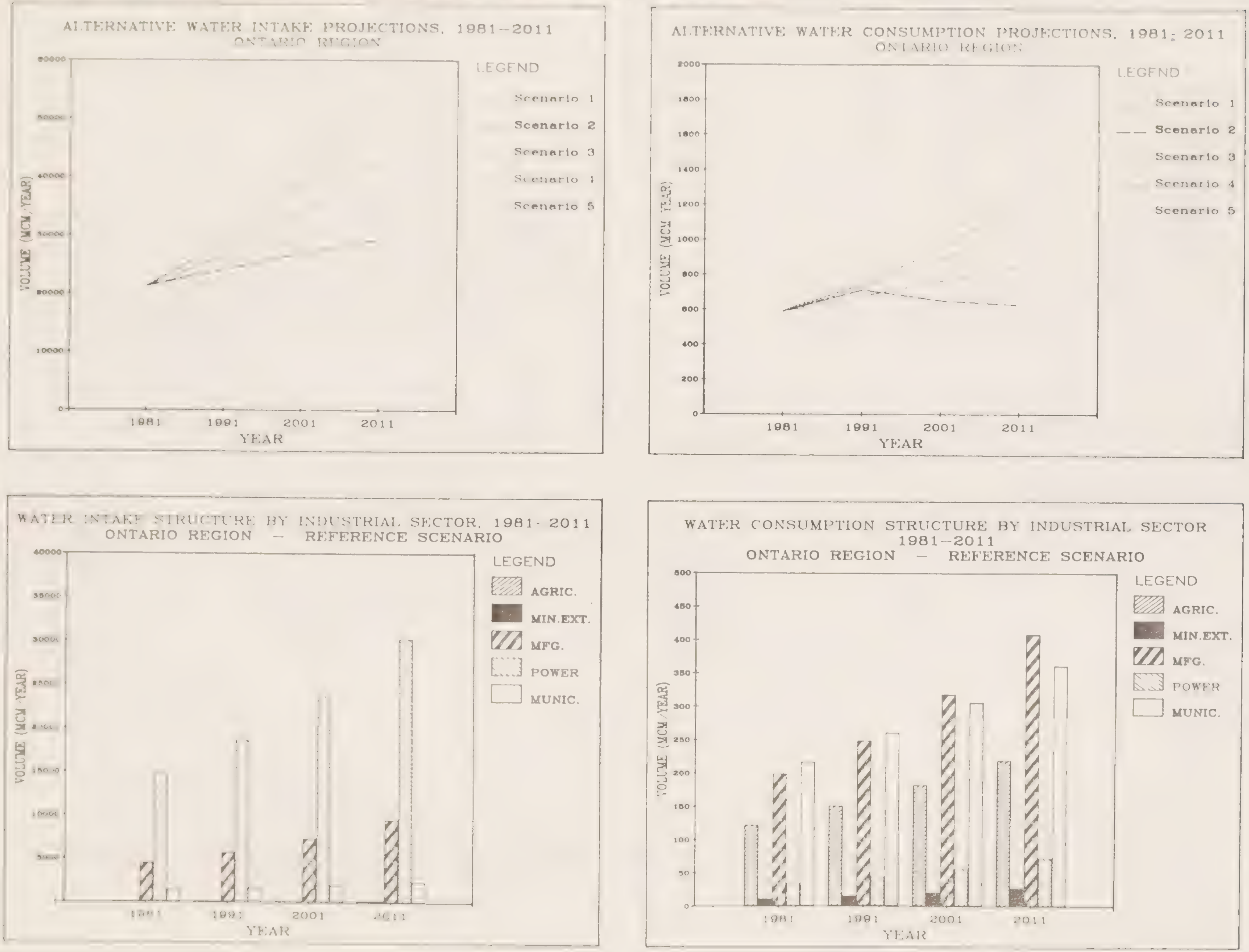


FIGURE 4.5 - WATER USE PROJECTIONS, PRAIRIE REGION, 1981 - 2011

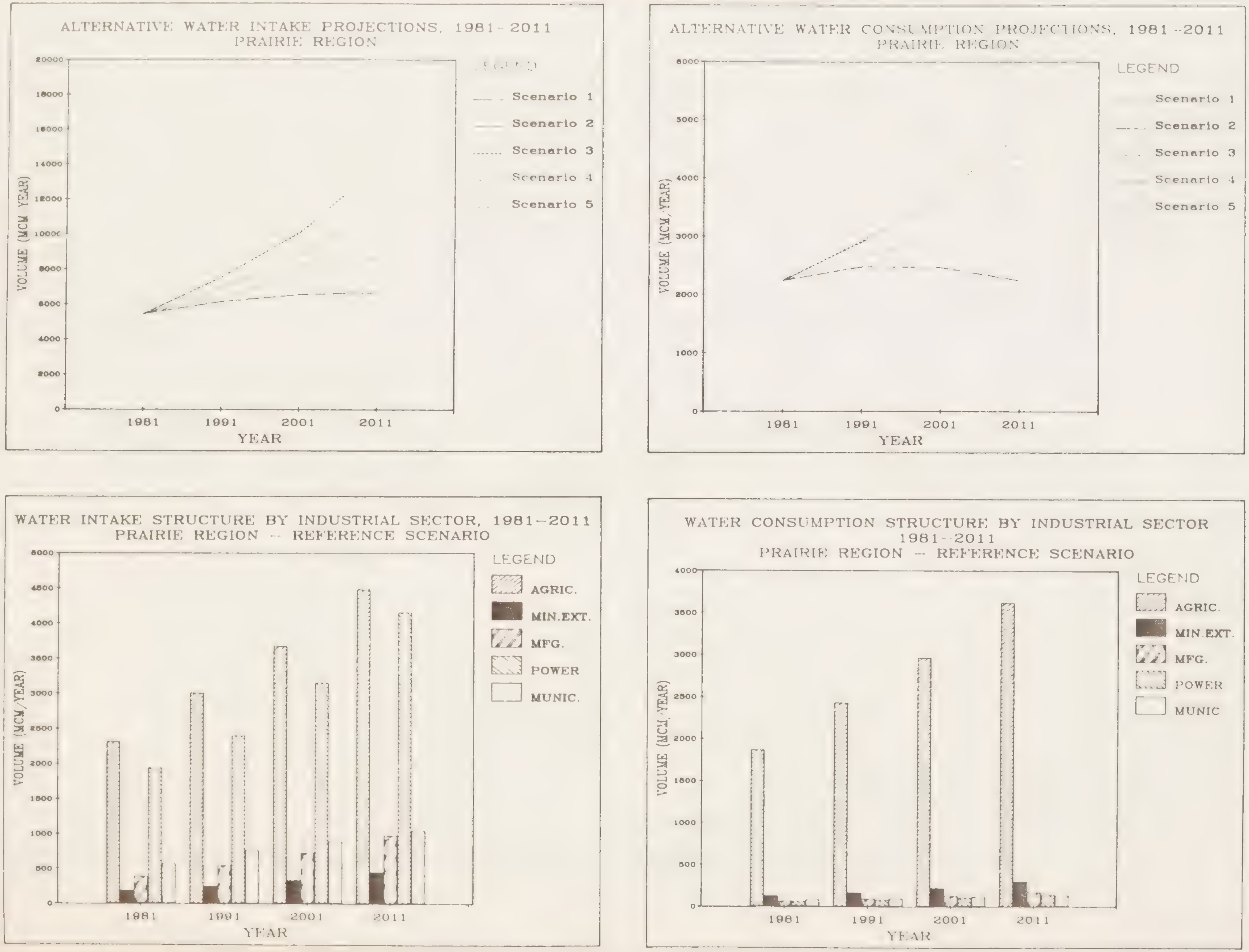


FIGURE 4.6 - WATER USE PROJECTIONS, BRITISH COLUMBIA REGION, 1981 - 2011

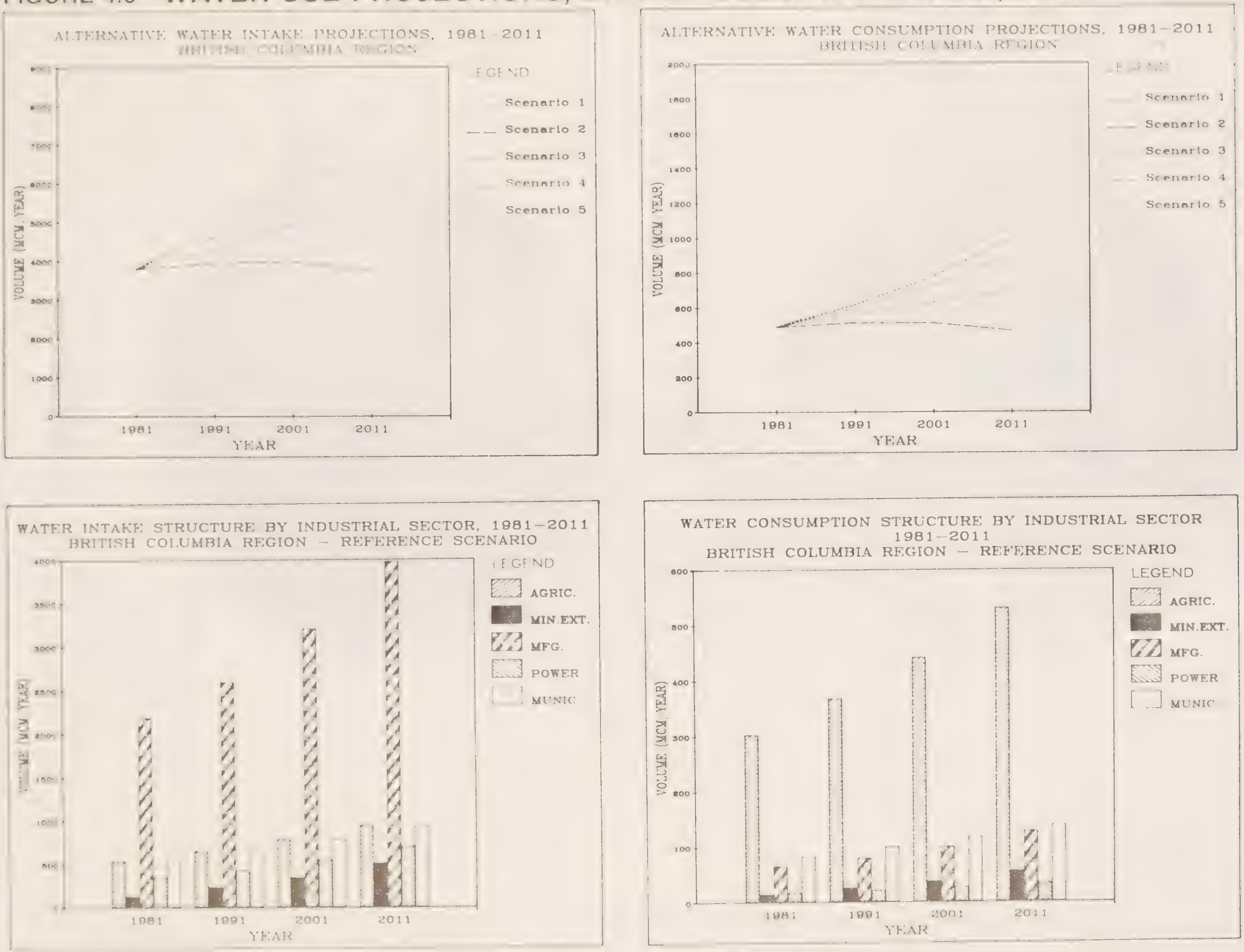
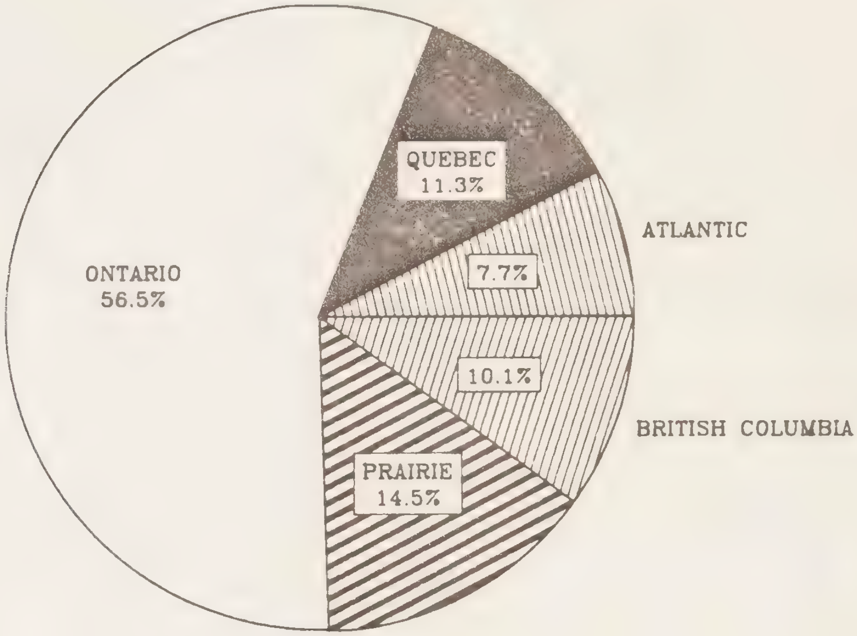
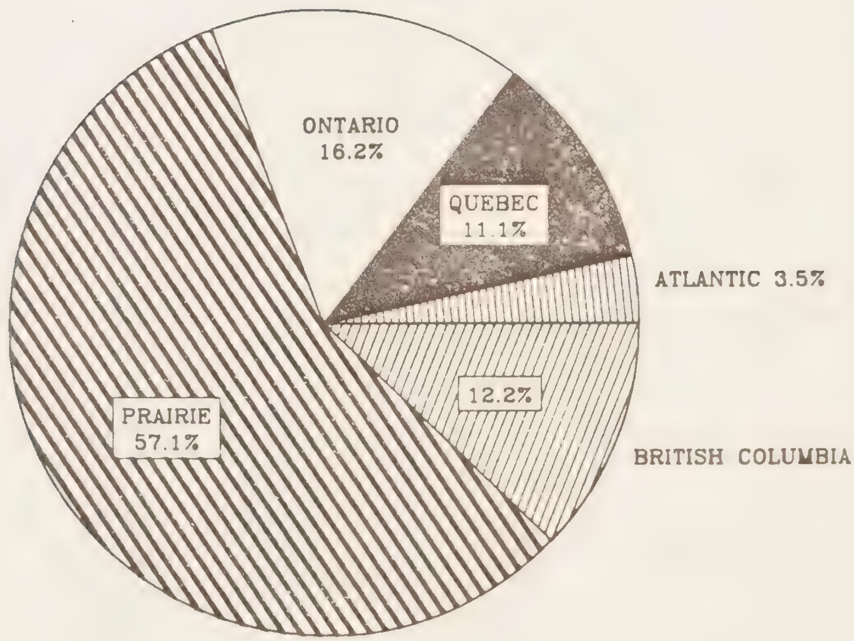


FIGURE 4.7 – WATER USE DISTRIBUTION BY REGION, 1981
CANADA

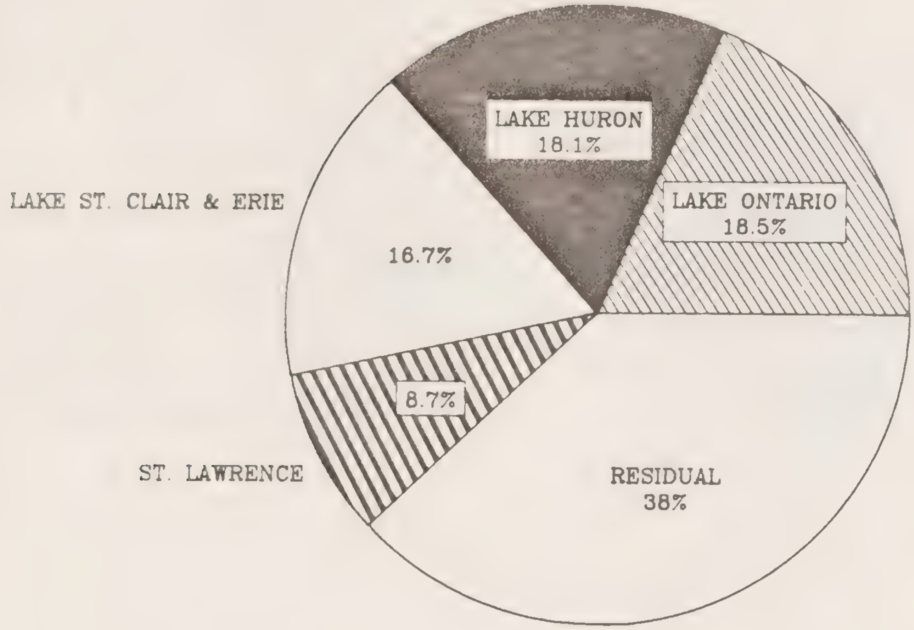


INTAKE

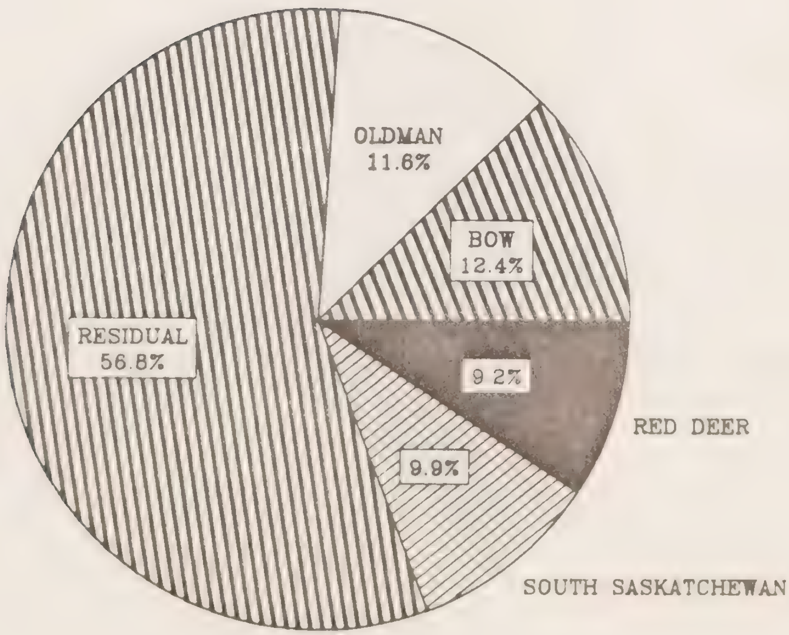


CONSUMPTION

FIGURE 4.8 – WATER USE DISTRIBUTION BY BASIN, 1981
CANADA

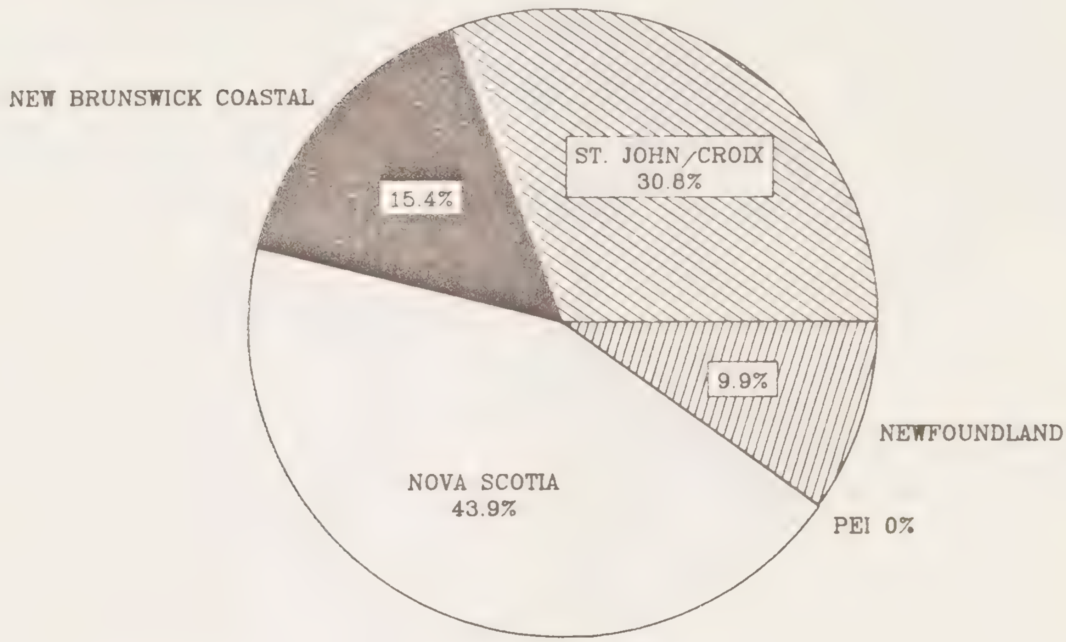


INTAKE

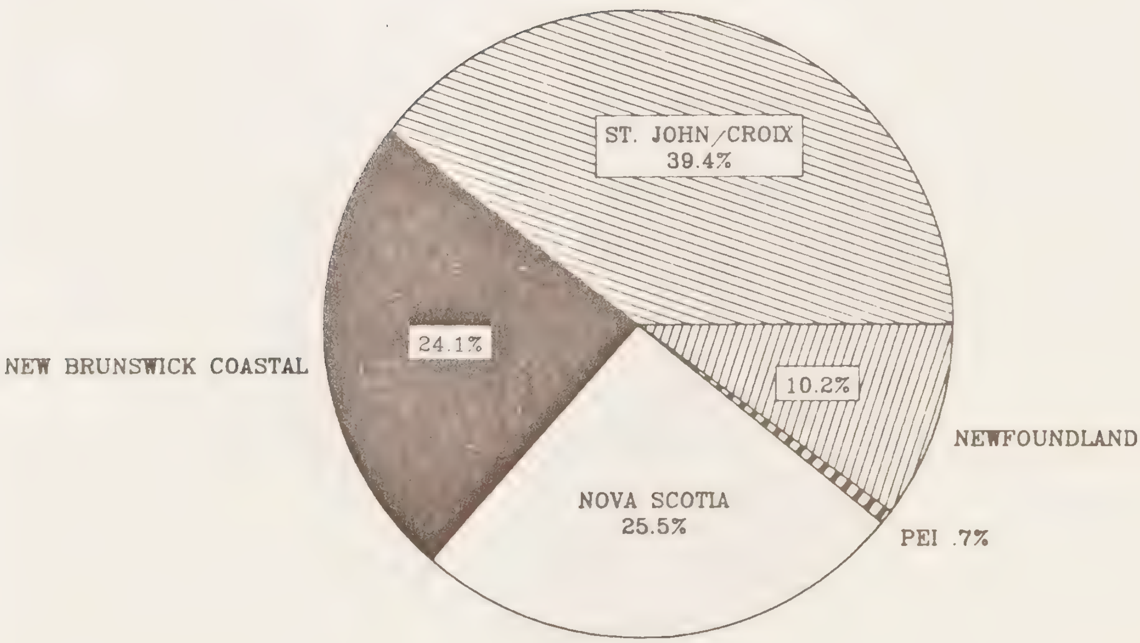


CONSUMPTION

FIGURE 4.9 – WATER USE DISTRIBUTIONS BY BASIN, 1981
ATLANTIC REGION

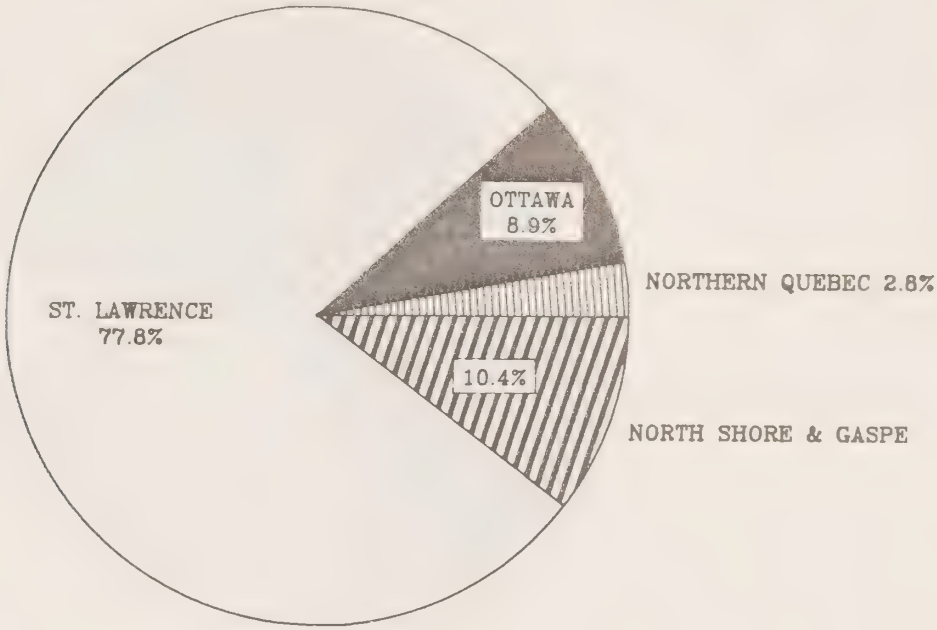


INTAKE



CONSUMPTION

FIGURE 4.10 – WATER USE DISTRIBUTIONS BY BASIN, 1981
QUEBEC REGION



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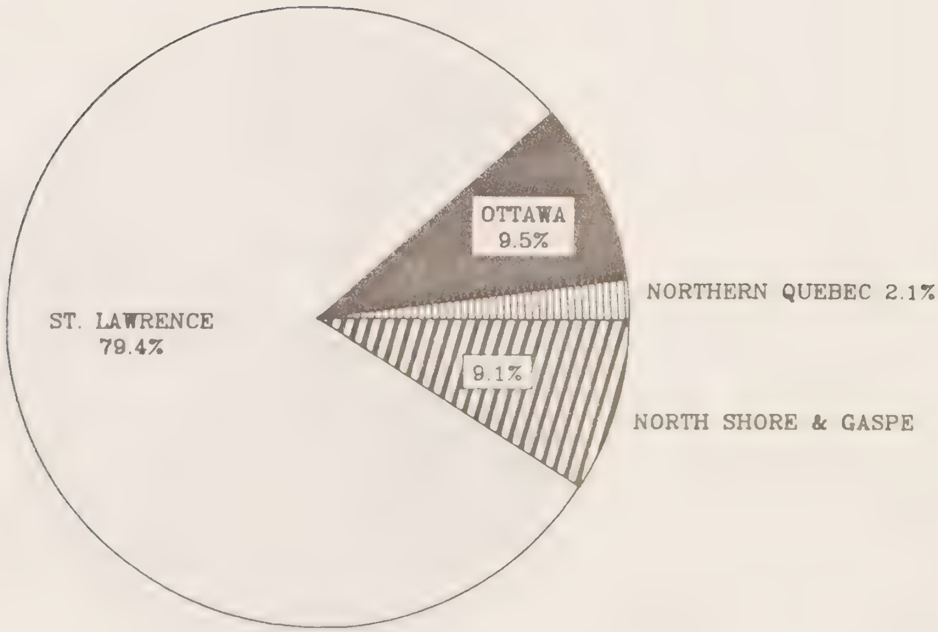
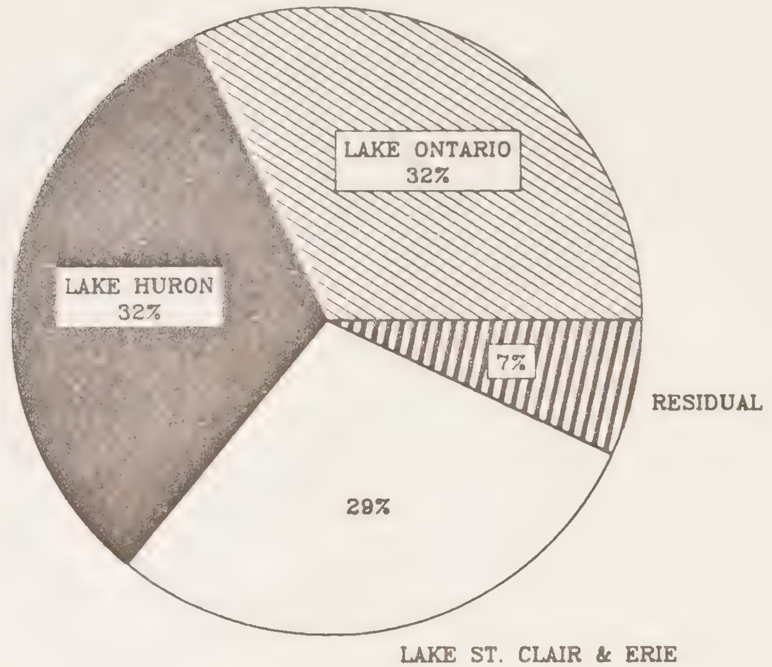


CONSUMPTION

FIGURE 4.11 – WATER USE DISTRIBUTIONS BY BASIN, 1981
ONTARIO REGION



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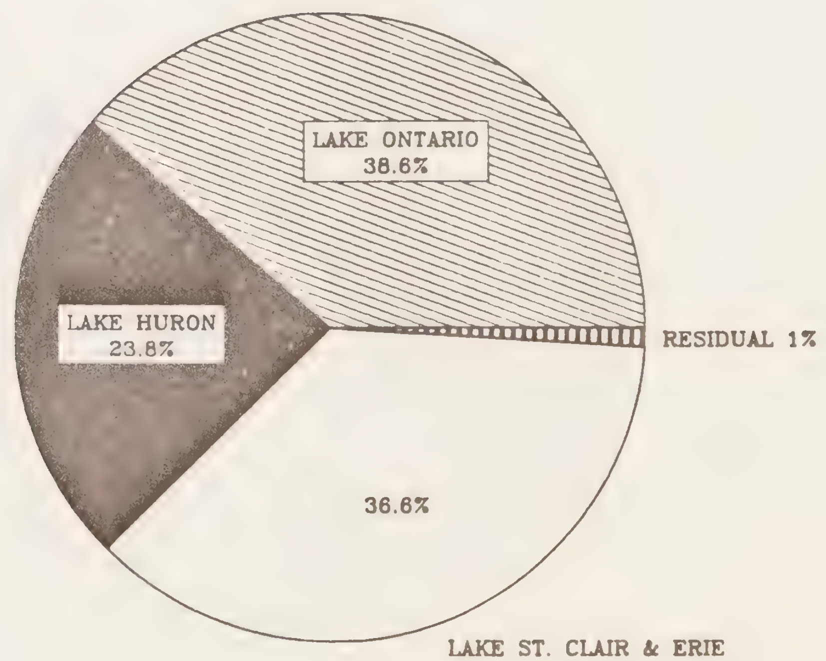
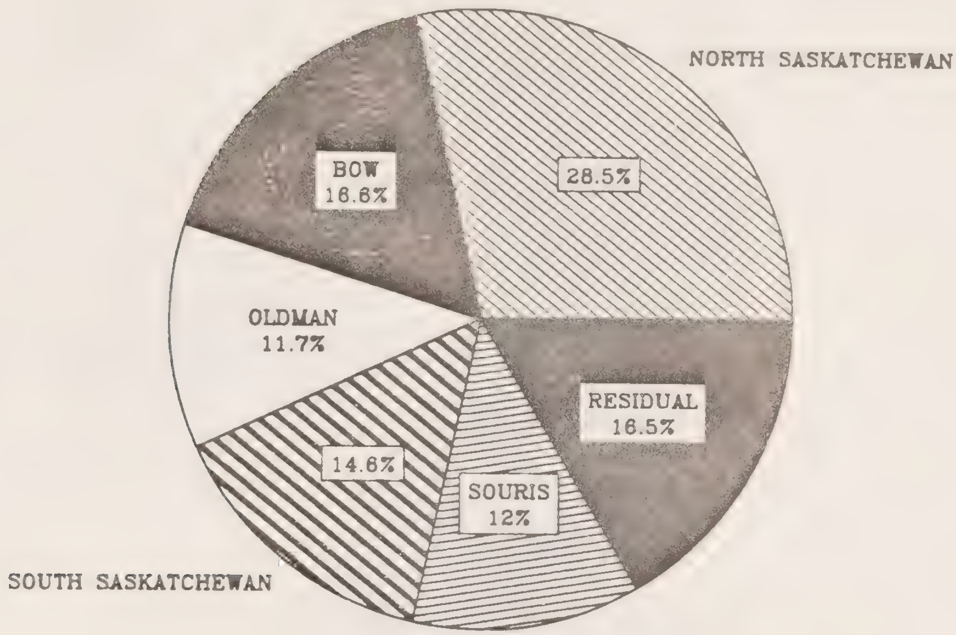


CONSUMPTION

FIGURE 4.12 – WATER USE DISTRIBUTIONS BY BASIN, 1981
PRAIRIE REGION



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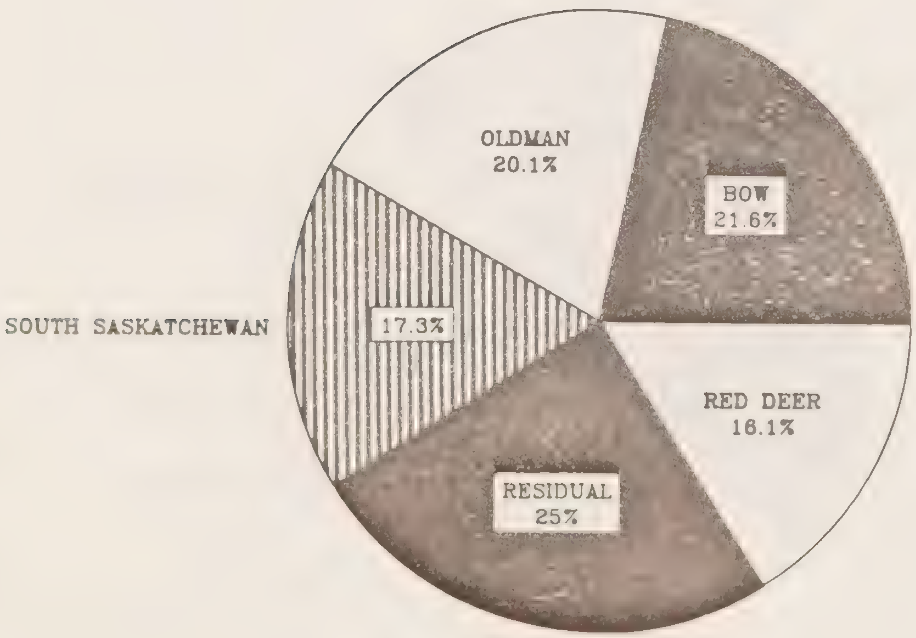
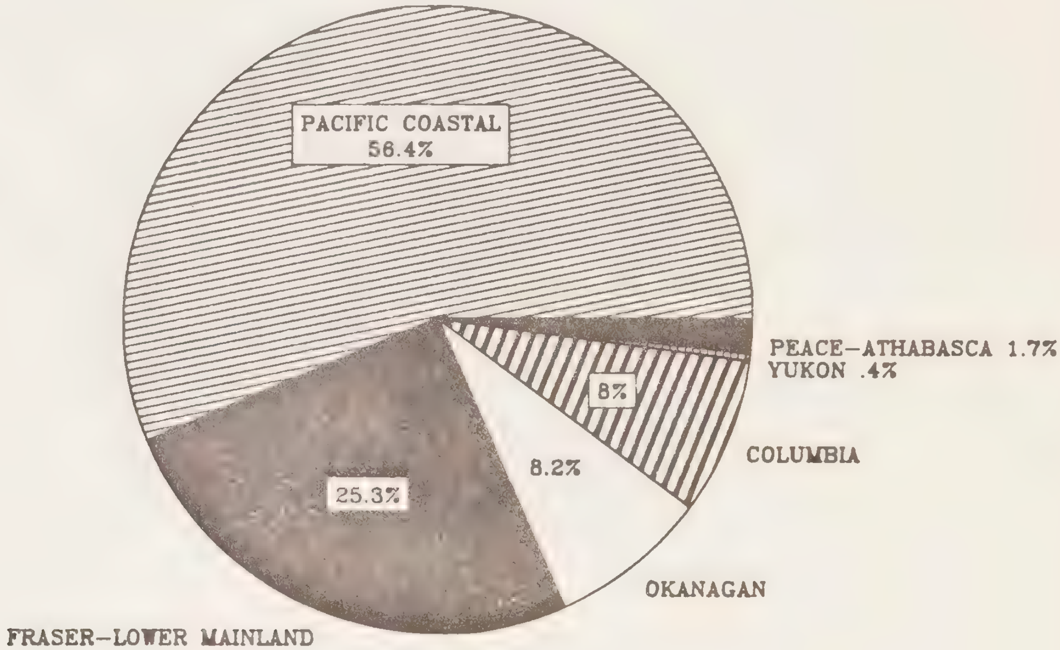


CONSUMPTION

FIGURE 4.13 – WATER USE DISTRIBUTIONS BY BASIN, 1981
BRITISH COLUMBIA REGION



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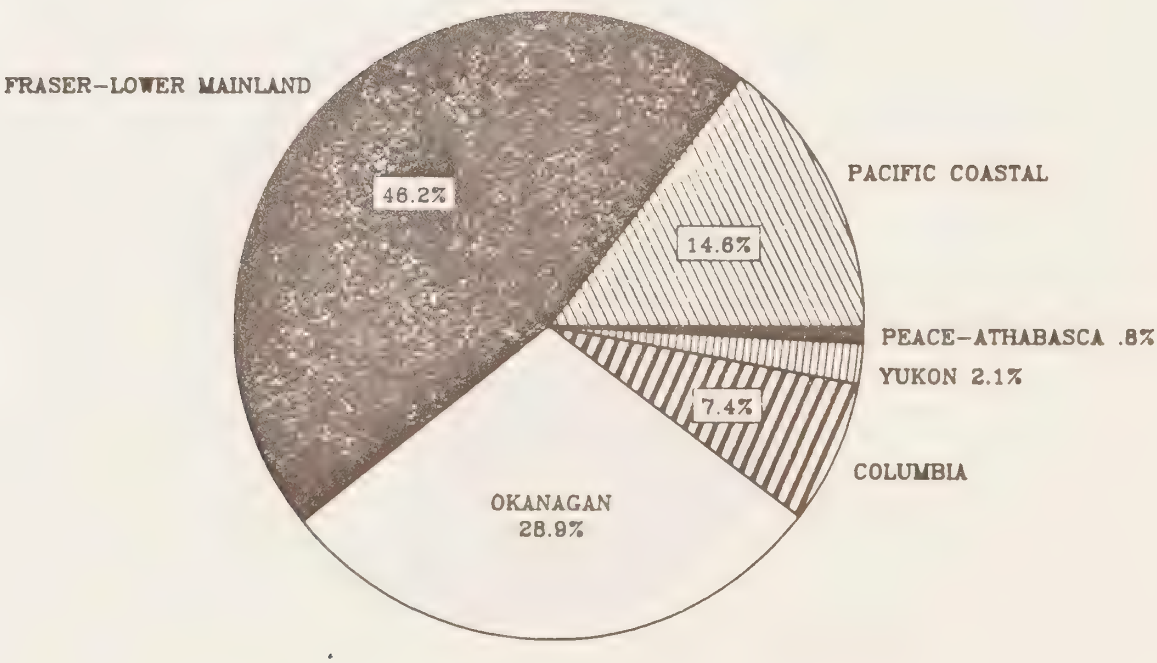


CONSUMPTION

essentially linear in nature, the patterns shown in the regions and their river basins follow closely the characteristics given above. In general the forecasts by region and basin reflect closely the economic base of each area. Interpretation of these data is left to the reader because of time constraints on this project.

4.2 Limitations of the Forecasts

As indicated in various places throughout this report, there are substatial limitaions of the forecasts, or projections, contained here. These limitations are dealt with in this section of the chapter. The problems of uncertainty are not mentioned further, as they have been addressed earlier.

4.2.1 Lack of Consideration for Small Spatial Units

The bulk of the work in this project was carried out at the national and regional levels. The river basin projections were merely a proportional breakdown of regional data. For this reason, local conditions, which might be important in determining future water use levels, were not studied, and, if they were not be included in aggregate tends, were not incorporated into the forecasts. In many situations, it would be the local developments which would be most important in giving rise to imbalances between supply and demand. Thus, the forecasts here should be used only as broad indicators of water use conditions over wide areas. In the next section, a method is suggested for overcoming this particular limitataion.

4.2.2 Lack of Supply Considerations

In Chapter 1, consideration of supply conditions was explicitly ruled out of this project, due principally to time and resource availability constraints. While such an arrangement was required here, the implication is that the water use forecasts are divorced from any physical reality. For instance, areas where the balance between supply and use are critical now or are becoming critical cannot be defined. Water quality conditions are also missing. The integration of supply and demand is a complex task, which must be undertaken at a fairly local level, as shown in the next section. For the present, however, the water use forecasts must stand by themselves.

4.2.3 Sectoral Detail

Due to the methodology used here, each of the sectors effectively received an equivalent amount of effort during the research phase. This was done to assure a reasonably consistent set of forecasts for Canada and its regions. However, it may be argued that the more important regional industries should have received more detail than the less important ones. In fact, this very arguement was put forth by the Advisory Committee for this project with respect to irrigation in the Prairie region. However, time did not allow a full sector-by-sector examination, and this remains as a task for the future.

4.2.4 Linear Modelling

The model used in this project in essentially linear in nature. This implies a high degree of uniformity in future water use patterns between regions, as indeed can be observed in

Figures 4.1 to 4.6, and in the constant proportions of each basin's water use to total regional use. The world, however, is not linear in nature, and future work is required in overcoming the structural rigidities of the model. More work is also required on the subject of forecasting technological conditions.

4.2.5 Limited Number of Variables

The model used here considered three major dimensions of forecasting: economic activity, production technology and water use practices. Minor consideration was given to the impact of water pricing and to varying population levels. However, many other variables, such as production process mixes, product mixes, plant operating practices and rates, etc., may also have influences on the level of water use. In future investigations such variables will require consideration.

4.2.6 Data Gaps

In compiling the data base for this report, all known sources of water use data were used, and it is thought that most of the withdrwal water use in Canada (i.e. over 95%) has been included. However, there are a few basins where no information on water use was available (e.g. the Churchill River basins, the Arctic Coast). These areas are not included in this report. Finally, the most serious data gap is the complete lack of data on non-withdrawal water use. Filling this gap will be a major task for the future.

CHAPTER 5

SIMULATION MODELLING - AN ALTERNATIVE APPROACH

In chapter 4, a number of limitations were suggested to the forecasts presented in this paper. Research is currently underway within the Inland Waters Directorate, Environment Canada, to overcome some of these inadequacies, particularly to create a methododogy which accounts for local conditions, which gives greater attention to locally important economic sectors and which incorporates water supply considerations. This research and some of its preliminary results are outlined here, because it constitutes the next step thought to be necessary in water use modelling. This approach could have been taken in the current project had resources (principally time) permitted. The object of presenting this material is to examine a practical method for linking water use and demand projections to water supply conditions. Although some empirical results are given, these are for primarily demonstrative purposes at this stage, for the required research for definitive statements about basin water balances is not yet complete. In other words, the material in this chapter is presented strictly in a research context, and, beyond the adoption of such an analytical approach, has no current implications for water planning and management.

5.1 Overview of the Model

The alternative method for approaching regional water demand forecasting employs a simulation model of fairly disaggregated areas. The simulation modelling approach is based upon defining the most crucial variables underlying sectoral water uses with a

river basin region, linking these in a logical fashion in a computerized model, building a forecasting algorithm and comparing forecasted water uses with available water supplies. The approach is a very flexible one, allowing a wide range of water supply conditions and alternative values of future variables. The model is outlined here, and then used to produce some projections for the Red Deer River Basin in Alberta. It is stressed here that the results given here are for demonstrative purposes only, and should not be treated with the same degree of reliability as those produced with the structural model used in the main part of the report

In contrast to the structural model, the simulation model uses river basins and subbasins as its primary spatial focus, and the areas within which to compare water supplies and uses. The region being analyzed must, therefore, be divided into subbasins, normally the area drained by a tributary or segment of a major river system. A subbasin must have a stream gauge near its mouth, with an adequate lengh of historic streamflow record. Base year (i.e. in this case 1981) data are required on the water use patterns of the various socio-economic activities in each subbasin. Water uses are projected by the model using various assumptions about economic and population growth, water use rates, specific significant developments which may be foreseen, and other forecasting parameters. These projected water use data (on withdrawal and consumptive use) are then combined for comparison with data on available water supplies, normally represented by streamflow data which have been naturalized by

removing the effects of historic withdrawals/consumptions. The model results are obtained at monthly intervals, by subbasin. The subbasin results can then be aggregated to produce comparisons of water supplies and uses by major river basin or by economic region.

5.2. Computation Procedure

The model's operation can be viewed as a three-stage process: (a) determination of future water uses; (b) determination of supply availability; and (c) comparison of future uses with available supplies. In setting up the model, the hierarchical relationship of subbasins within the main basin must be defined; irrigation areas must also be placed in their proper spatial positions within the subbasins. Upstream basins are examined first, comparing uses to available supplies. The surplus water is passed to the next downstream subbasin. Local subbasin inflows, irrigation return flows from other subbasins, diversions and surplus flows from upstream are all considered in computing water availability. In this way, the impacts of all upstream water uses and water sources are accounted for in analyzing downstream basins. The model structure is presented in Figure 5.1. The calculation detail for each subbasin, or node in the model, is illustrated in Figure 5.2.

The following material constitutes a brief description of the principal methods used in the model, based upon more extensive documentation (Canada, 1983, 1984).

FIGURE 5.1 - MODEL STRUCTURE

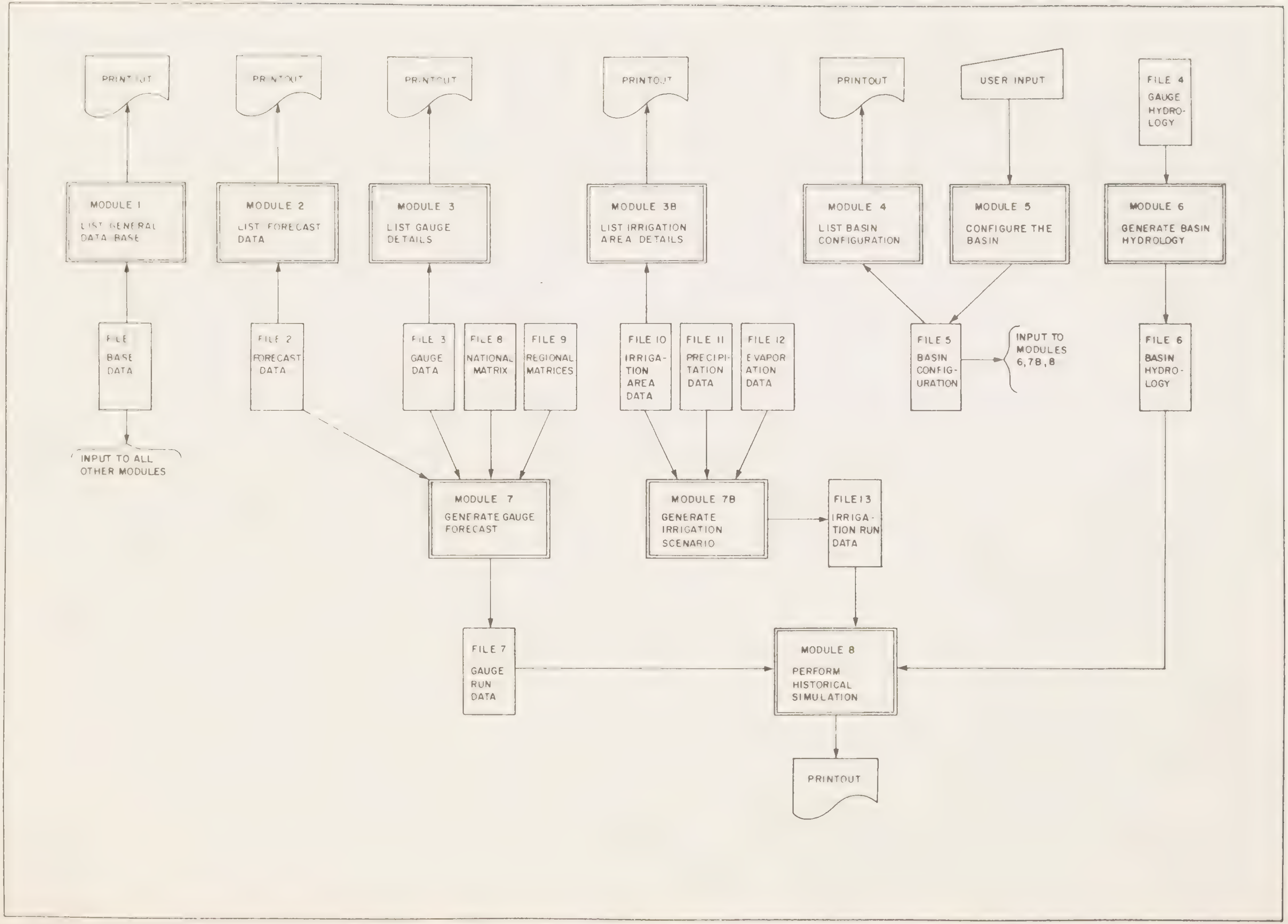
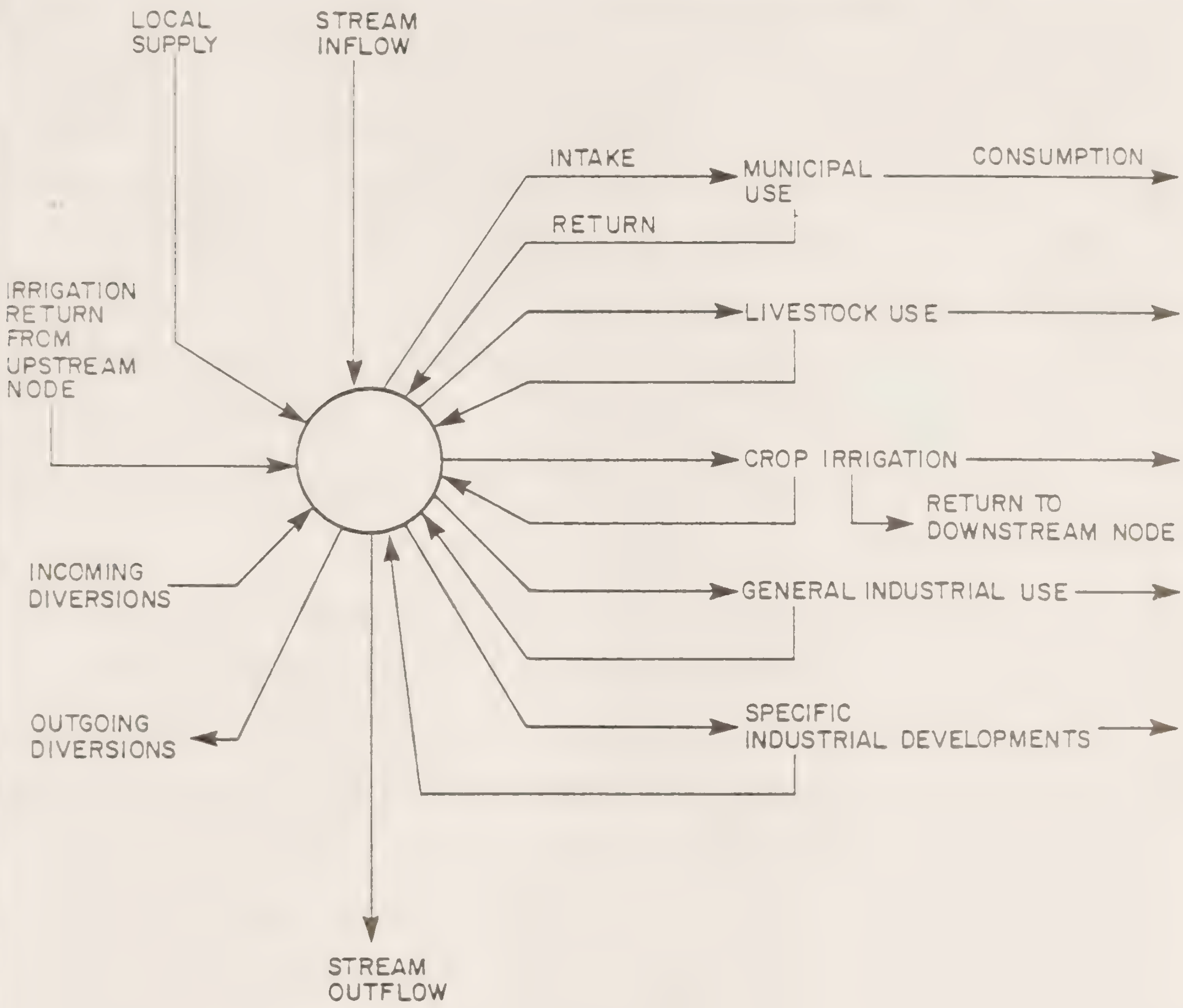


FIGURE 5.2 - CALCULATION DETAIL AT EACH NODE



NET INFLOW = LOCAL SUPPLY + STREAM INFLOW + DIVERSIONS IN − DIVERSIONS OUT + IRRIGATION RETURN FROM UPSTREAM

$$\text{OUTFLOW} = \text{NET INFLOW} - \sum^{\text{ALL USES}} (\text{INTAKE} - \text{RETURN}) \text{ AT THE NODE}$$

5.2.1. Water Use Analysis

Four basic water uses are considered in the model: municipal, industrial, irrigation and livestock. These four uses ncompass the thirty sectors of the structural model outlined earlier. In addition, two optional uses can be considered, namely outgoing diversions and major anticipated additions to the industrial base which would not be included in the economic trend. Both intake and withdrawal are computed. In-stream water uses are considered as minimum flow constraints, as will be outlined below.

For the municipal, industrial and livestock sectors, heavy reliance is placed at present on water use coefficients. For irrigation water use, however, the coefficient approach was inadequate because of the high temporal variability of irrigation requirements, depending upon precipitation and other climatic and perational factors. In the version of the model used here, irrigation water requirements have been calculated using a detailed submodel of crop water requirements. In future versions of the model, municipal and industrial uses will also be the objects of detailed submodels, but those submodels were not available for use in this project.

For the municipal sector, the model requires forecast data describing population growth. These data, available at the provincial level, are apportioned to the subbasin, based on baseline population data. The model utilizes the forecasts of future population and the municipal water use rates to establish the total municipal water requirements in each subbasin.

Industrial water use is categorized into the 30 basic industrial sectors, as defined by Statistics Canada. The basic unit used in the model to gauge industrial activity is the dollar output of the sector (expressed in 1981 dollars). The total water intake and consumption use of each industry is, therefore, expressed in litres per annual 1981 dollars of industrial output. Future water uses are calculated based on forecasts of real growth in each industrial sector (expressed in 1981 dollars).

The model incorporates industrial input-output matrices for each economic region in order to maintain the backward and forward production linkages between various industries. Similarly, the interregional trade estimates for industries, as produced by Statscan, have been included. Therefore, the impact of growth in one sector in one economic region is reflected in the growth of that sector in another economic region.

The model combines the forecasts of value of shipments with the water use coefficients to establish the total volume of water required by industries in the subbasin.

Forecasts of livestock water uses are calculated, by livestock type, following an approach which is similar to the municipal sector.

Irrigation water requirements are calculated based on detailed modelling of crop water needs, giving consideration to irrigated area under different crop types, irrigation types, precipitation (in-season and out-of-season), crop evapotranspiration, soil moisture levels and various operational factors, such as level of irrigation, application efficiency and

delivery efficiency. The calculations are performed in units of millimetres per hectare, on a monthly basis within the cropping season (May to September), and for a historic period of years determined by the precipitation record.

Figure 5.3 is a flow chart of the irrigation water use submodel. More details on the submodel's computational procedure, assumptions, etc. can be found in Canada (1984).

Forecasting irrigation water needs requires information on the future area under irrigation, by crop, soil and irrigation types as well as foreseen operational factors. The model calculates irrigation water diversions and return flows for each irrigation area for combination with the other water uses.

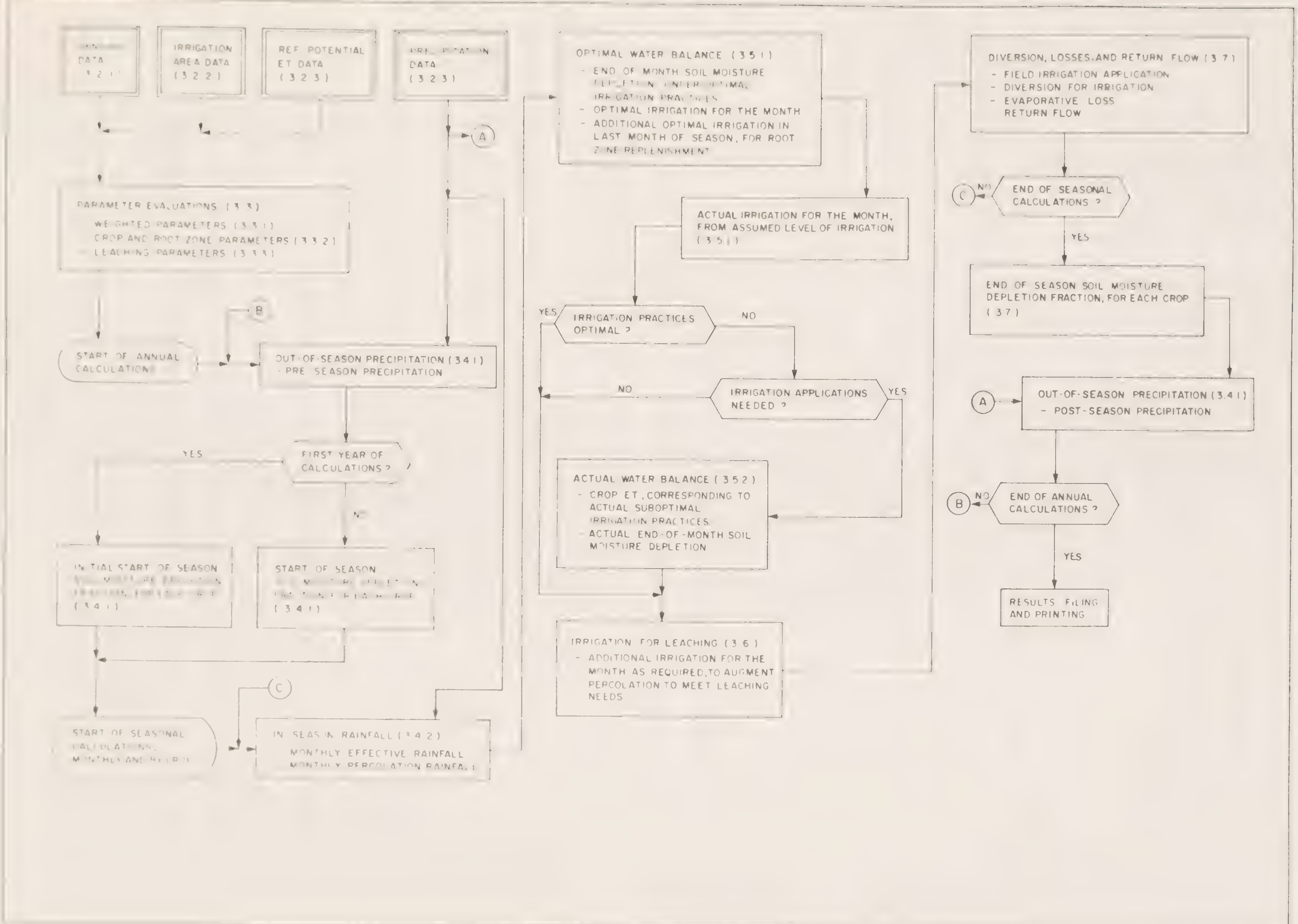
In-stream uses (e.g. recreation, water quality) are presently considered in the model based on minimum flow constraints. The model provides the option to specify monthly minimum flow constraints at the outlet from the subbasin. Months when these minimum flows are violated are flagged in the output and the frequency of their occurence is documented.

5.2.2 Water Availability

Water supplies from surface water sources are represented in the model by monthly (natural) streamflow data. The model, in its present form, requires that streamflow data be adjusted for the effects of reservoir regulations.

Provision has also been made in the model for including water supplies from groundwater sources. At this stage of model development, however, groundwater supplies are modelled using ad hoc procedure. Specific aquifers and their limitations, maximum

FIGURE 5.3 - FLOW CHART FOR EVALUATION OF IRRIGATION AREA WATER USE



withdrawals and recharge rates have not been included.

It is also possible to simulate water transfers from one subbasin to another or from outside the major basin under study.

5.2.3 Comparison of Water Supply and Use

Water supply and use are compared monthly over the period of available hydrologic record, by calculating the ratio of water use (both withdrawal and consumption) to supply for each month. A frequency histogram of these ratios is produced and the months with the most critical (highest) ratio of use to supply are identified. The outflow from each subbasin is also compared with the minimum flow constraints, and any violations and their severities are reported.

5.3. Background for the Selected Simulations

As noted above, the primary purpose of this demonstration is to illustrate the capabilities of the simulation modelling approach for water use:supply studies. This approach is most useful for evaluating the impacts of future development scenarios on the water resources of an area at a local level, and by extension at regional or interjurisdictional levels. The analysis covers four simulations chosen to highlight the potential water use conflicts between energy developments on one hand and irrigation development and minimum flow requirements on the other hand. These simulations, especially the two concerned with projections to the year 2001, are related somewhat to the scenarios produced by the structural modelling, although they are not as

comprehensive, and cover different time periods. Again, the analysis presented here is intended for demonstration purposes and should be viewed only in this context.

5.3.1. The Study Area

The Red Deer basin is located between areas in southern Alberta which are heavily developed for irrigation, and more northerly areas which have large currently-operating and potential water using energy projects. The Red Deer basin itself has considerable potential for expansion in both of these economic sectors, but it has also been viewed as a possible source of supplementary water for neighboring basins. Water management options are further compounded by possible alternative minimum flow requirements for instream uses and for meeting the water apportionment agreement with Saskatchewan, the neighboring province downstream.

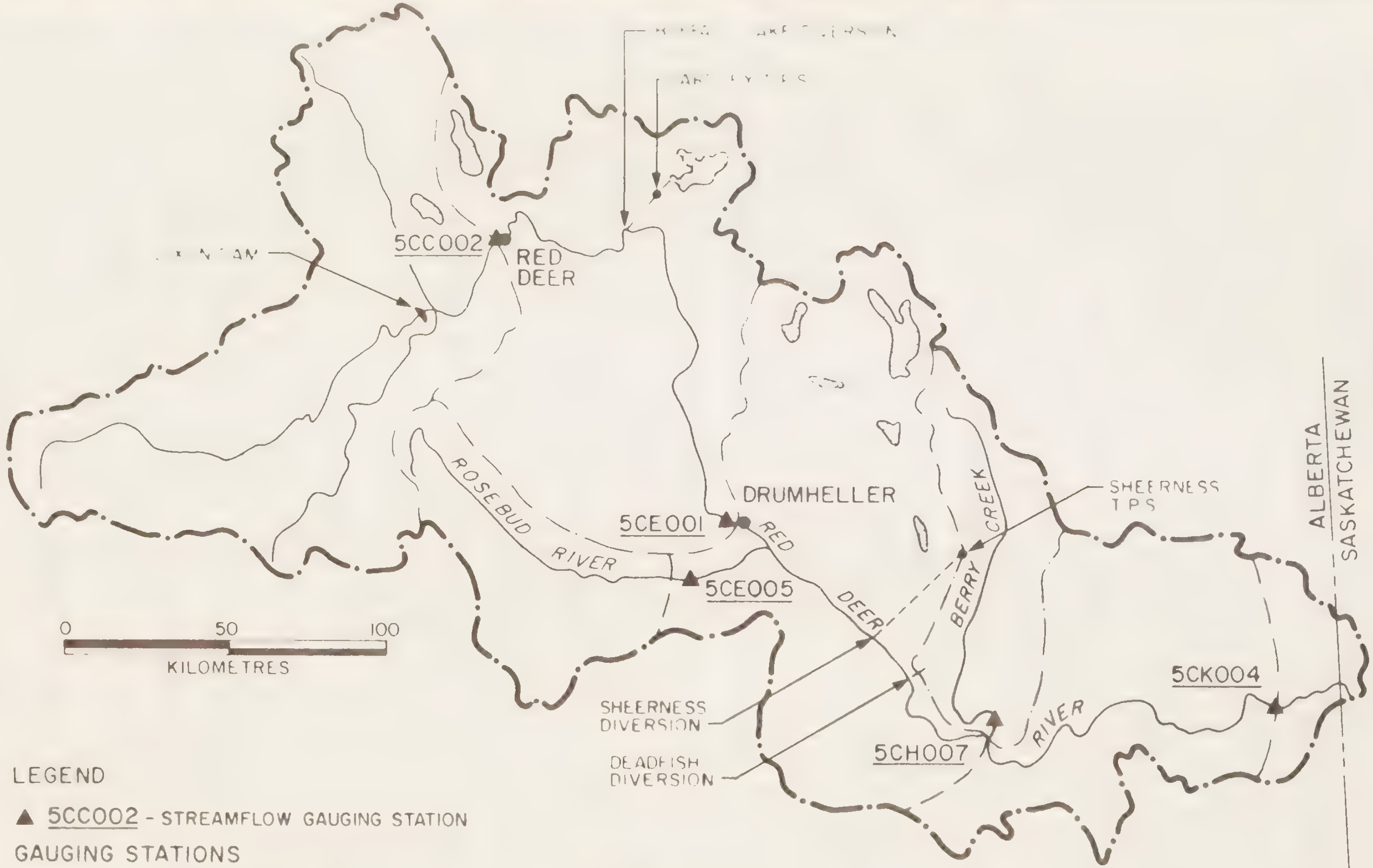
Figure 5.4 shows the Red Deer basin and its component subbasins, together with the gauging stations used for the analysis. The flow network incorporating irrigation areas is shown in Figure 5.5.

5.3.2. Description of the Simulations

The simulations chosen for investigation are as follows:

- Simulation of current water use, 1982. (The use of 1982 as a base year was chosen because of the output currently being received from the consultants working on the project. This simulation was done to verify the model).
- Committed scenario, 1982-1987 (This simulation examines the effect of developments already planned or underway for the

FIGURE 5.4 - RED DEER RIVER BASIN - SUBBASINS AND GAUGING STATIONS



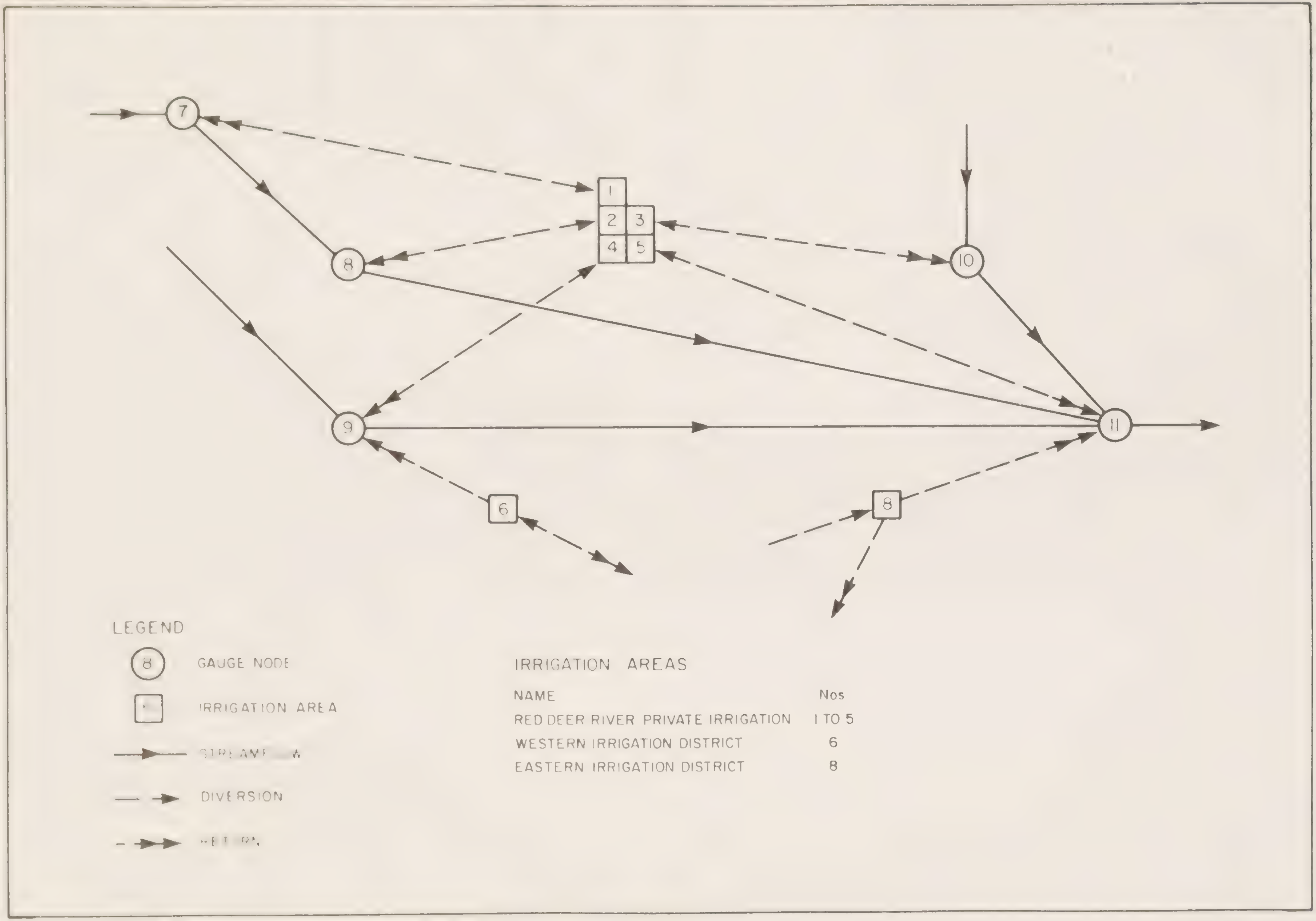
LEGEND

▲ 5CC002 - STREAMFLOW GAUGING STATION

GAUGING STATIONS

I.D No	LOCATION	NODE No
5CC002	RED DEER RIVER AT RED DEER	7
5CE001	RED DEER RIVER AT DRUMHELLER	8
5CE005	ROSEBUD RIVER AT REDLAND	9
5CH007	BERRY CREEK NEAR THE MOUTH	10
5CK004	RED DEER RIVER NEAR BINDLOSS	11

FIGURE 5.5 - RED DEER RIVER BASIN - FLOW NETWORK INCLUDING IRRIGATION AREAS



basin.)

- Simulation of future scenarios, 1981-2001

  (a) High energy and high irrigation requirements

  (b) High energy and high minimum flow requirements

In all scenarios, population, industrial and livestock forecasts were chosen as follows:

- population- Statistics Canada (198) population scenario 1 (fertility increase plus some imigration);
- Industrial- Economic Council of Canada (197), 1981-1990 projection
- Livestock- Low growth

Irrigation and energy production (and their water uses) as well as minimum flow requirements were allowed to vary, as will be specified below. Thus the water use forecasts at this stage are partial in nature.

Most of the data for this analysis were taken from studies carried out at the Inland Waters Directorate, Environment Canada (Canada, 1983; 1984; and 1985). A recently completed study by Alberta Environment (Albeta, 1984) aided in the scenario formulation. Three previous regional studies by the Canada West Foundation (1982), the Prairie Provinces Water Board (Canada-Alberta-Saskatchewan-Manitoba, 1982), and the Saskatchewan-Nelson Water Board (Canada-Alberta-Saskatchewan-Manitoba, 1972) were also used.

5.4. Simulation of Current Conditions (Simulation 1)

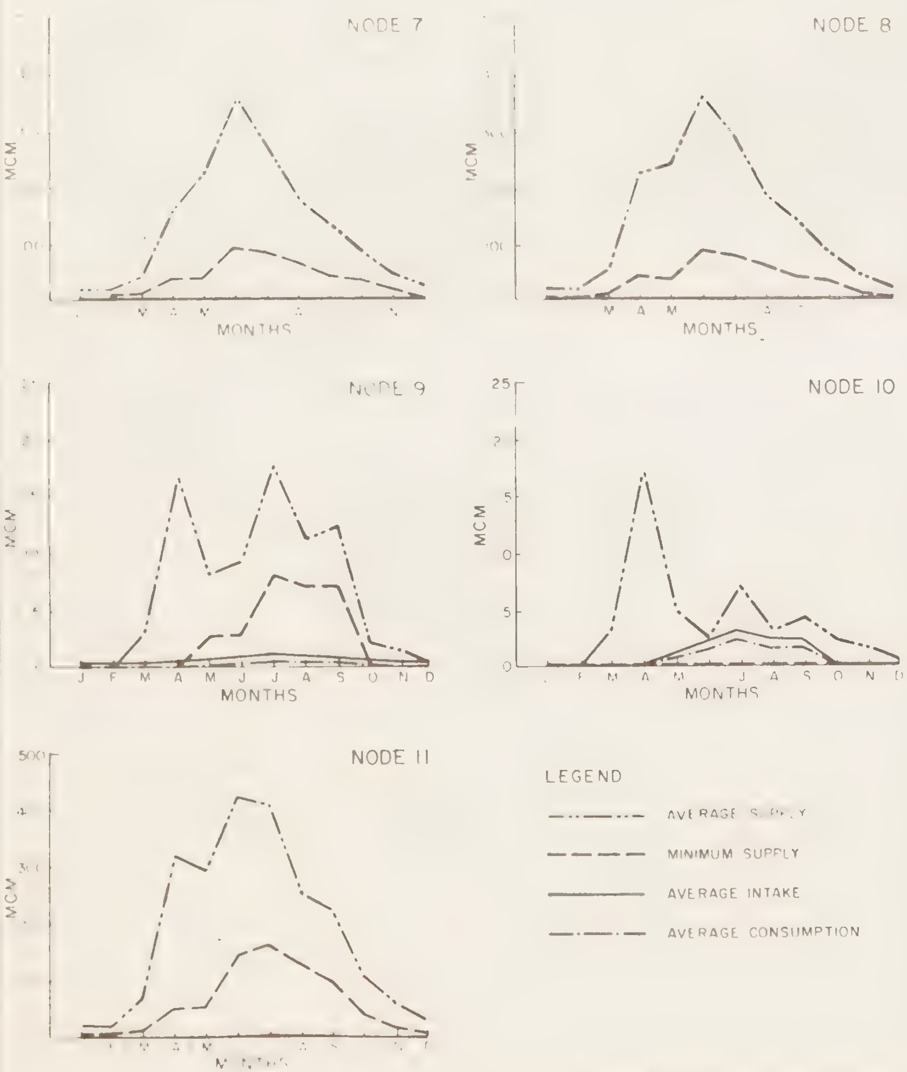
5.4.1 Assumptions

Water use for the Red Deer basin in 1982 were simulated using current population and activity levels. No special energy developments were built in, and all irrigation was set at the 1982 level (i.e. about 7 100 ha. of private development plus 115 430 ha. of public development in the Western and Eastern Irrigation Districts, located in the Bow River basin. Return flows from these two districts are routed both to the Bow River and to the Red Deer River basins. No diversions, other than the irrigation flows, were incorporated. Minimum flows were place at the level of the average apportionment flow to Saskatchewan at Bindloss (Node 11) of 18 cubic metres per second, which is approximately equal to 75% on the minimum historic natural flow. This corresponds roughly to the current situation. The flow was distributed by month according to the historic pattern. Flows were taken as adjusted naturalized stream flows, 1912-1967, produced by the Prairie Provinces Water Board (PPWB)(see Canada-Alberta-Saskatchewan-Manitoba, 1972).

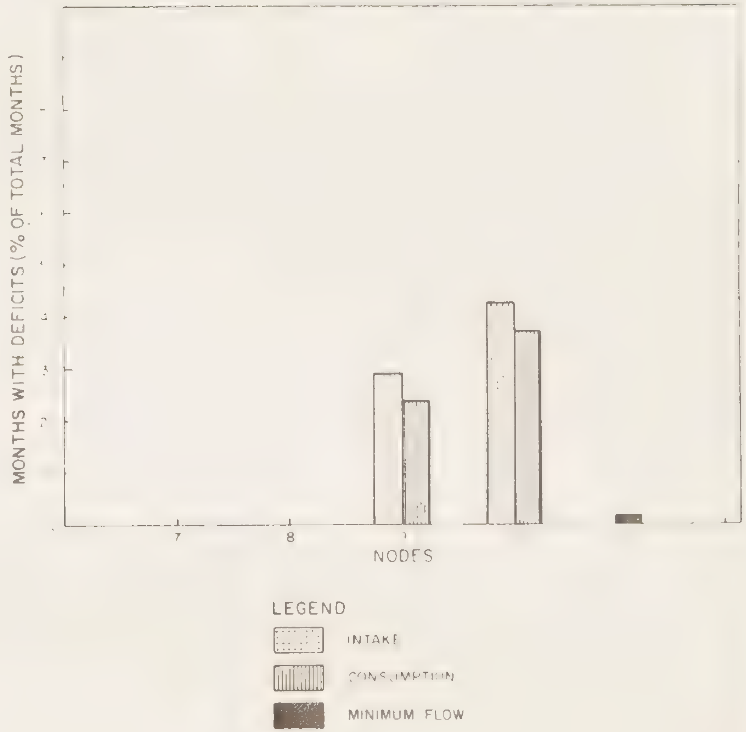
5.4.2. Results

Figure 5.6 summarizes the results of this initial simulation exercise. The dominant water supply pattern is for very low flows during the winter months and peak flows in June and July. This pattern is similar to that of all river basins in the area. Winter flows of zero are frequent in the Rosebud River and Berry Creek (nodes 9 and 10). Zero summer flows are also frequent natural occurences in these streams. In the case of the Rosebud River, these zero-flow conditions are mitigated by high return

FIGURE 5.6 - RED DEER RIVER BASIN - BASE SCENARIO 1982



MONTHLY DISTRIBUTIONS



MINIMUM SURPLUS* (% OF AVAILABLE FLOW)

NODE	INTAKE		CONSUMPTION		MINIMUM FLOW	
	S	A	S	A	S	A
7	94	92	98	98	N	N
8	96	96	99	99	N	N
9	86	81	95	93	N	N
10	D	D	D	D	N	N
11	97	98	98	99	45	46

S: SEASONAL (MAY - SEPT.)
D: DEFICIT
A: ANNUAL
N: NOT APPLICABLE
* BASED ON THE YEAR WITH MINIMUM SUPPLY

DEFICITS AND MINIMUM SURPLUS

flows from the Eastern and Western Irrigation Districts. Combining the withdrawal water uses with the supply conditions, substantial water surplusses occur in the Red Deer main stem subbasins (nodes 7, 8 and 11). Frequent winter supply deficits occur in the Rosebud and Berry tributary subbasins, primarily due to zero flow conditions. It is assumed that groundwater sources are used in the winter. Frequent deficits also occur in the summer in the Berry Creek subbasin, due both to the low natural flow conditions and to a relatively high level of irrigation development. The same comments also apply to water consumption.

Occasional monthly violations of the assumed minimum flow requirements occur at Bindloss (node 11). This is due to the assumed monthly flow distribution. On a seasonal or annual basis there is a surplus supply.

5.5. Simulation of the Committed Development Program (Simulation 2)

5.5.1 Assumptions

Certain developments in the basin were assumed as committed developments, and formed the basis for the second simulation. Population, livestock and industrial production were forecasted as outlined earlier. In addition, in the energy sector, the Shearness thermal power station, located in the Berry Creek subbasin, is taken as developed to the 750 MW level, with an annual intake of 54 MCM. This plant will be served by diversion from the Red Deer River during 8 months of the year, with intake from storage only during the 4 winter months. Return flows from the power station were assumed to be held in storage for release during the irrigation season (May through September).

Full development of irrigation areas to the level of 10 400 ha. along Berry and Deadfish Creeks (node 10) was assumed, following implementation of the Berry and Deadfish diversions. Nominal expansions were assumed elsewhere in the basin to a total of 16 000 ha. overall. Also some increased developments were assumed in the Eastern and Western Irrigation Districts to 120 000 ha., with partially increased irrigation efficiencies.

Three intrabasin diversions were assumed. For recreational and environmental purposes, 1.8 cubic metres per second are diverted from the Red Deer above Drumheller to Buffalo Lake. To support the power plant at Sheerness, 2.0 cubic metres per second are diverted from the Red Deer below Drumheller. For irrigation, 1.0 cubic metres per second are withdrawn for the Red Deer below Drumheller to Deadfish Creek.

With regard to flows, the 1912-1967 adjusted naturalized flows from PPWB were use. The Dickson dam was incorporated above Red Deer, and operated to maximize minimum winter flows. In this manner, a minimum winter flow of 18.4 cubic metres per second can be supported throughout the winter. A minimum flow of 18 cubic metres per second at Bindloss was assumed, as in the first simulation. Also, a minimum release from the Dickson Dam of 16 cubic metres per second was assumed, as in the original design criteria for the dam.

5.5.2 Results

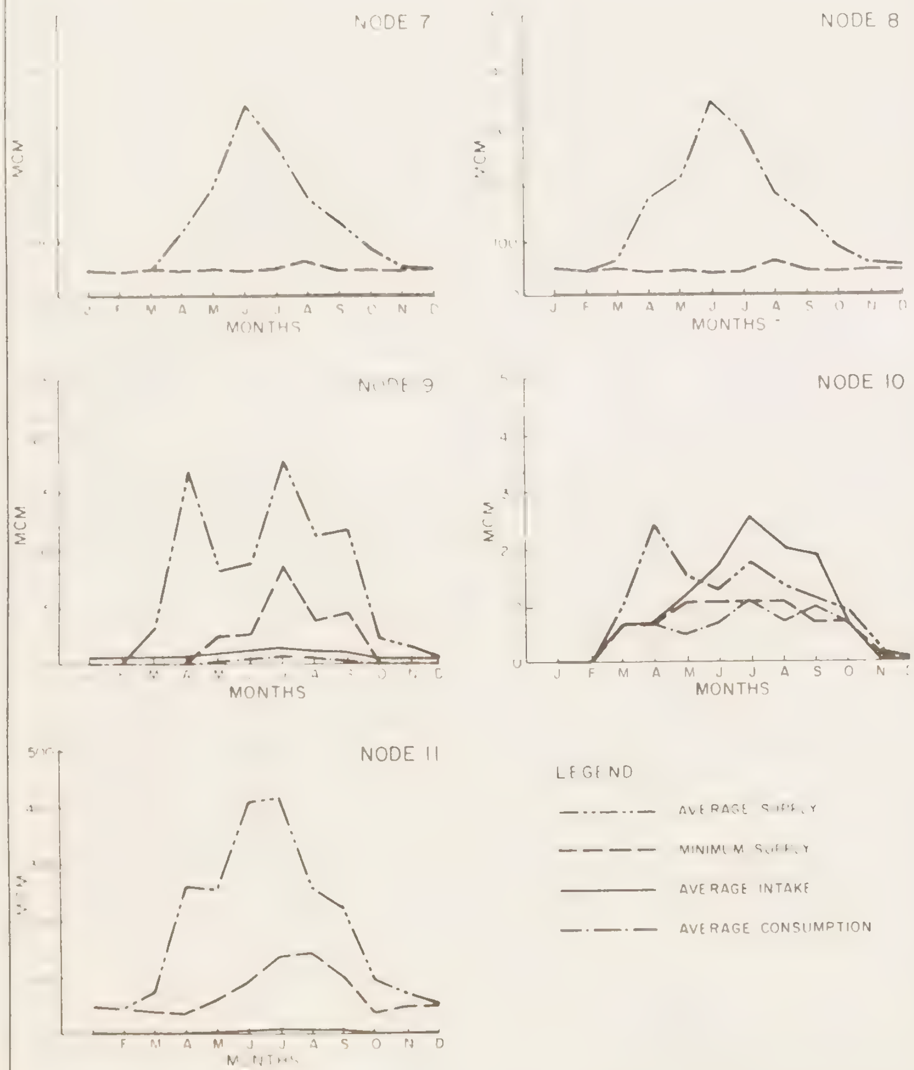
As a result of this simulation, notable improvements can be seen (Figure 5.7) in winter flows along the Red Deer mainstem (nodes 7, 8 and 11), due to the specified operation of the Dickson Dam. In the years of very low flow, an almost constant flow is maintained at the two upstream nodes, unaffected by unregulated inflows downstream. Diversions into the Berry Creek subbasin (node 10) significantly improve supply conditions in the summer months.

With regard to the impact of water use on the supply pattern, substantial surplus supplies occur along the Red Deer main stem subbasins (nodes 7, 8 and 11), as in the 1982 run. Negligible changes from the 1982 base occur in the Rosebud subbasin (node 9). Thermal power and irrigation production in the Berry subbasin (node 10) have a marked impact in increasing the frequency of deficits with respect to water intake on both a monthly basis, and on a seasonal and annual basis. The impacts of consumptive use are similar to those outlined for intake, with one notable exception. The frequency of summer deficits in the Berry subbasin decreases sharply, and there are now negligible deficits on a seasonal basis. The Sheerness power plant and related storage is seen to be the key to combined power and irrigation in this subbasin.

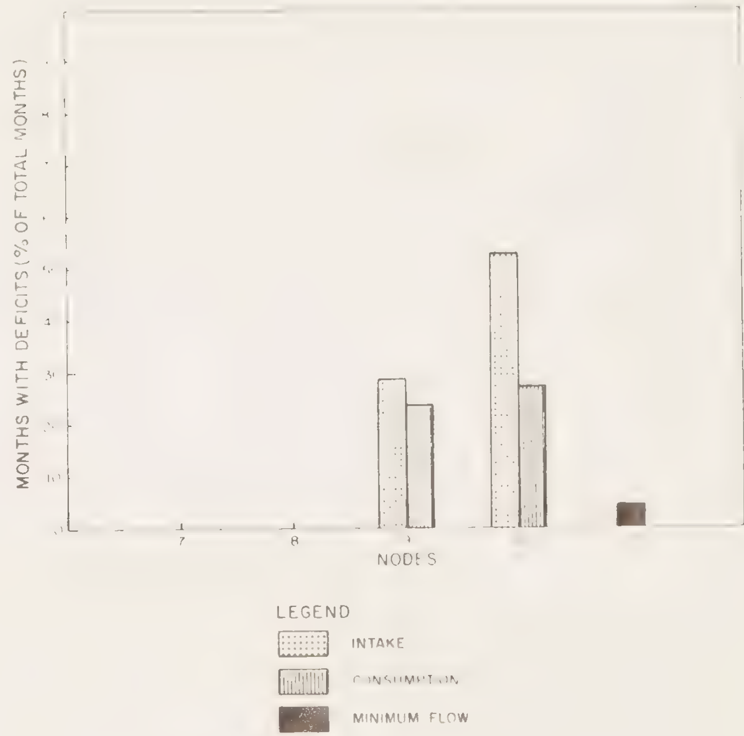
5.6. Simulation of High Energy-High Irrigation Requirements (Simulation 3)

The third simulation exercise examines the impact of developments which calls for both high energy and high irrigated

FIGURE 5.7 - RED DEER RIVER BASIN - COMMITTED SCENARIO 1987



MONTHLY DISTRIBUTIONS



MINIMUM SURPLUS* (% OF AVAILABLE FLOW)

NODE	INTAKE S	INTAKE A	CONSUMPTION S	CONSUMPTION A	MINIMUM FLOW S	MINIMUM FLOW A
7	92	92	97	97	38	24
8	94	94	98	99	N	N
9	83	77	93	92	N	N
10	D	D	D	12	N	N
11	95	97	97	98	34	44

S = SEASONAL (MAY-SEPT.) D = DEFICIT
A = ANNUAL N = NOT APPLICABLE
* BASED ON THE YEAR WITH MINIMUM SUPPLY

DEFICITS AND MINIMUM SURPLUS

agricultural production by year 2001 . In this manner some of the trade-offs between the two sectors can be seen as they apply to the areas's water resource base.

5.6.1 Assumptions

The flow record used here is the same as for the other simulation runs. The Dickson dam is also incorporated. Thermal power production at the Sheerness plant is doubled (i.e. compared to simulation 2) to 1500 MW, with annual intake requirement of 85 MCM. Diversion and storage arrangements similar to those outlined in the previous section are made. In addition, the Ardley thermal power station below Red Deer (node 8) is developed to 2000 MW, with a yearly intake of 88 MCM. Withdrawal at this plant take place from surface sources during 8 months of the year, with winter withdrawals from storage only. Return flows from the thermal plant are routed to Buffalo Lake, during the 8 month period in which surface withdrawals occur ; these return flows are for recreational and environmental purposes, with no subsequent return flow to the Red Deer main stem.

With respect to irrigation, full development of potentially irrigable land (outside of the two organized irrigation district) occurs, to a total of 120 000 ha. Of this total 104 000 ha. are developed in the lower Red Deer main stem subbasin below Drumheller (node 12). In the organized irrigation districts, expansion takes place to the 153 000 ha. level, accompanied by fully improved irriation efficiencies, producing relatively low return flows.

In support of these developments, 1.8 cubic metres per second is diverted from the Red Deer main stem as in simulation 2. This is in addition to the Ardley power plant diversions from the same location. The 4.0 cubic metres per second diverted to Sheerness continues as in simulation 2, as does the summertime diversion from Deadfish Creek.

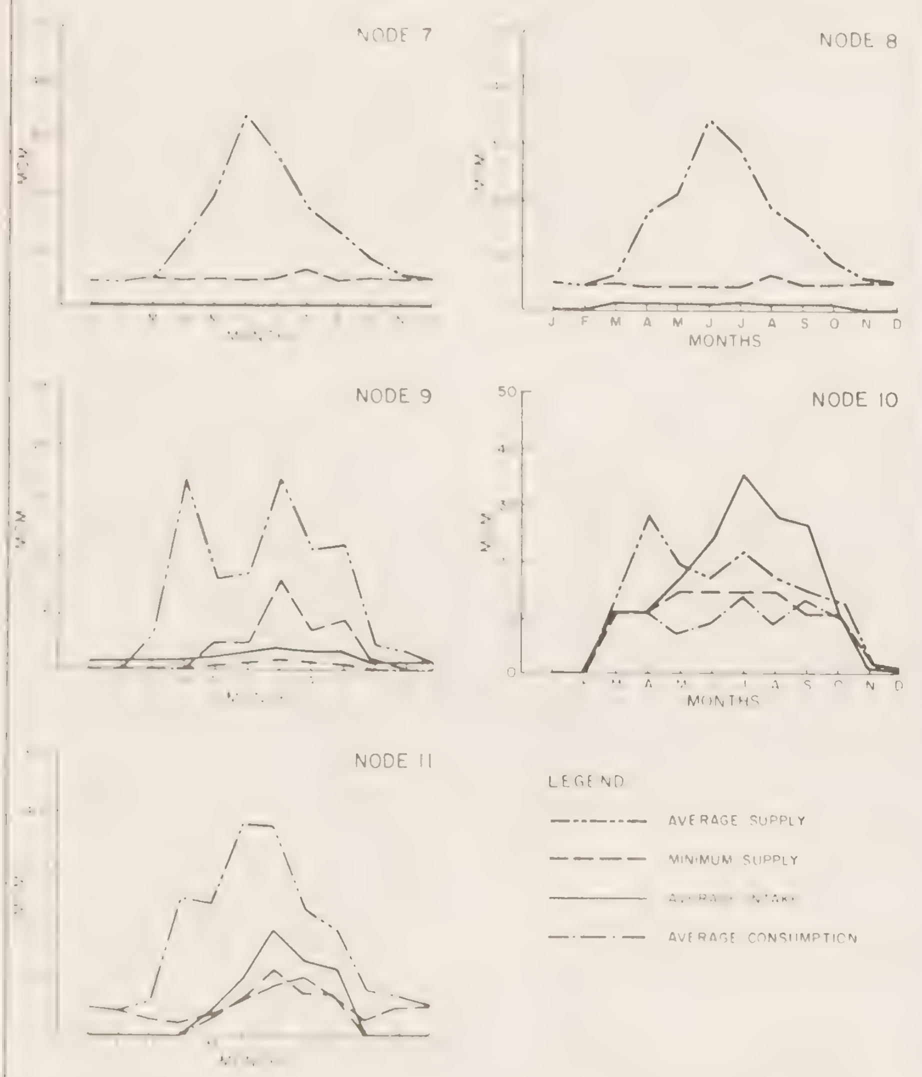
An average apportionment flow to Saskatchewan at Bindloss is reduced to 12 cubic metres per second, about equal to 50% of the minimum natural flow. This flow is distributed through the year as in simulation 2. Also minimum release from the Dickson Dam is again set at 16 cubic metres per second (node 7).

5.6.2. Results

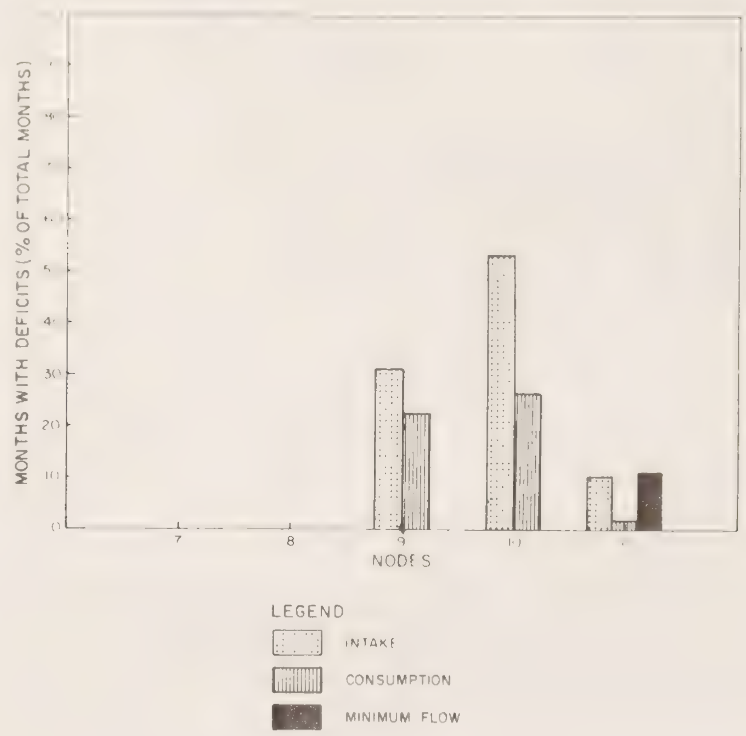
Further improvements in the summer water supply, over and above those of simulation 2, occur as a result of the increased diversion to the Sheerness power station (Figure 5.8). A noticeable reduction in summer water supplies to the lower Red Deer subbasin (node 11) result from the lower irrigation return flows from the Bow River basin, as a result of increased irrigation efficiencies.

Water intakes increase substantially above Drumheller (node 8) as the Ardley thermal power plant comes on stream. Minimum annual surplus, however, is still substantial, at 78% of available flow. Further increases in thermal power and irrigation water withdrawals in the Berry subbasin (node 10) approximately counteract the effects of the increased diversion, making the overall impact about similar to that for simulation 2. Significant summer increases in withdrawal in the lower Red Deer

FIGURE 5.8 - RED DEER RIVER BASIN - FUTURE SCENARIO 2001, HIGH ENERGY AND HIGH IRRIGATION



MONTHLY DISTRIBUTIONS



MINIMUM SURPLUS* (% OF AVAILABLE FLOW)

NODE	INTAKE S	INTAKE A	CONSUMPTION S	CONSUMPTION A	MINIMUM FLOW S	MINIMUM FLOW A
7	89	88	96	96	37	24
8	74	78	8	86	N	N
9	73	63	30	88	N	N
10	0	1	0	12	N	N
11	D	20	3	50	D	8

S = SEASONAL (MAY - SEPT.)　　D = DEFICIT

A - ANNUAL　　N = NOT APPLICABLE

* BASED ON THE YEAR WITH MINIMUM SUPPLY

DEFICITS AND MINIMUM SURPLUS

(node 11) result in a frequency of deficicts about 10% of the time on both a monthly and seasonal basis. Seasonal diversion for Sheerness constitutes only about 10% of total seasonal intake in the subbasin; most of the water use is for irrigation.

The same comments as made for water intakes also apply to consumptive water use, except in the lower Red Deer subbasin. Here, there is only about a 2% frequency of deficits on a monthly basis and none on a seasonal basis. Therefore, assuming appropriate use of return flows, available water resources may be sufficient to support minimum flows. This statement may be modified by the requirements of minimum flows.

Specified minimum flows are met at Red Deer (node 7), as in simulation 2. However, the reduced allocation of flow at Bindloss is not always met. The frequency of outflow deficits is about 10% on both a monthly and seasonal basis, but is only 2% on an annual basis. This is due to the regulated winter flow releases from the Dickson Dam. Thus apportionment levels represent the principal constraint to development on the scale used in this simulation.

5.7 High Energy and High Minimum Flow Requirements (Simulation 4)

The last simulation examines the interface between energy development and minimum flows. These flows are required (a) to meet apportionment requirements, and (b) for environmental (represented here by fishing) and recreational (canoeing) purposes.

5.7.1. Assumptions

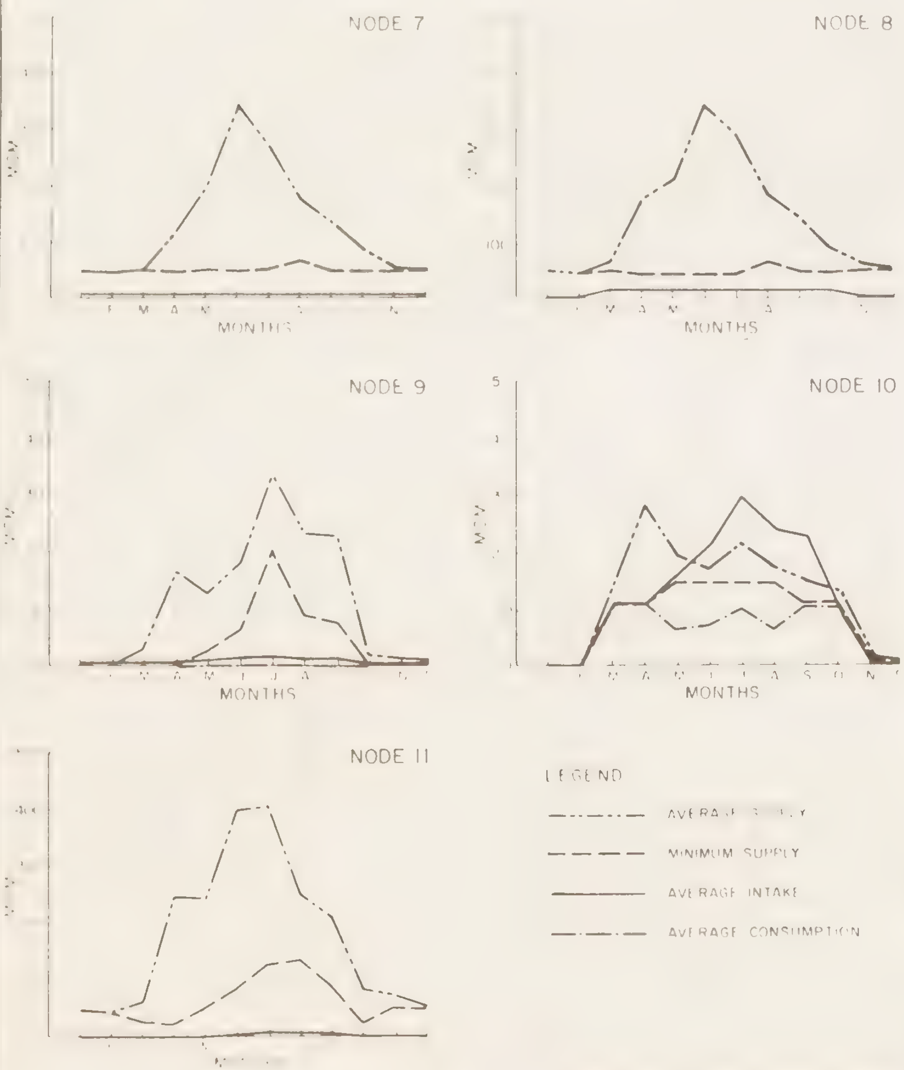
Flows are established as in the other simulations, with the Dickson Dam incorporated. With regard to energy production, Sheerness and Ardley power stations are set up as in simulation 3 (i.e. 1500 MW and 2000 MW respectively, with appropriate water use patterns and supply arrangements). Private irrigation development is held to 16 000 ha. as in simulation 2. Full development of the Eastern and Western Irrigation Districts takes place to the 233 000 ha. level, with fully improved efficiencies producing increased return flows. Water diversion arrangements are as outlined in simulation 3.

Apportionment flows average 18 cubic metres per second at Bindloss, and minimum release from Dickson Dam is set at 16 cubic metres per second. Additional minimum flow allowances are made at Red Deer (node 7) Drumheller (node 8) and Bindloss (node 11) to satisfy the environmental and recreational requirements outlined earlier. Average requirement at the three locations are 18, 27 and 36 cubic metres per second respectively for fish. In the peak summer months, these are about double. For canoeing, summer flow requirements are 25, 30 and 40 cubic metres per second respectvely.

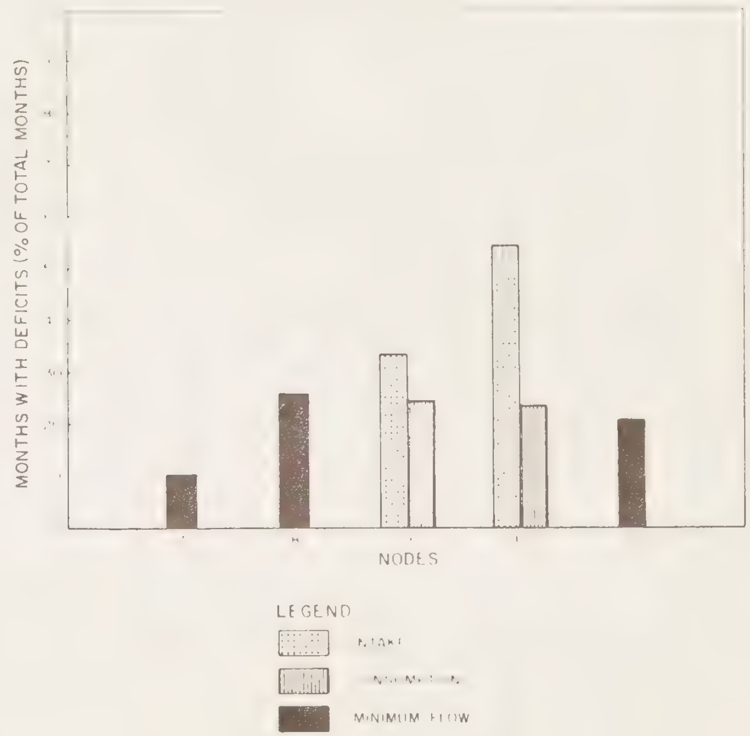
5.7.2. Results

The simulation results are presented in Figure 5.9. Supplies in the upper and middle Red Deer main stem subbasins (nodes 7 and 8) are as in simulation 3. Noticeably increased summer flows occur in the Rosebud subbasin (node 3) due to higher return flows from the two public irrigation districts. This is also reflected in an improved

FIGURE 5.9 - RED DEER RIVER BASIN - FUTURE SCENARIO 2001, HIGH ENERGY AND HIGH MINIMUM FLOW



MONTHLY DISTRIBUTIONS



MINIMUM SURPLUS* (% OF AVAILABLE FLOW)

NODE	INTAKE S	INTAKE A	CONSUMPTION S	CONSUMPTION A	MINIMUM FLOW S	MINIMUM FLOW A
7	83	88	97	97	D	D
8	74	79	81	86	D	D
9	90	84	97	95	N	N
10	D	D	23	25	N	N
11	94	96	97	98	D	D

S = SEASONAL (MAY - SEPT.)　　D = DEFICIT

A = ANNUAL　　N = NOT APPLICABLE

* BASED ON THE YEAR WITH MINIMUM SUPPLY

DEFICITS AND MINIMUM SURPLUS

supply situation in the lower Red Deer (node 11).

Intakes above Drumheller (node 8) and in the Berry subbasin related to thermal power generation are unchanged from simulation 3. However, in the latter, reduced irrigation development reduces total intake. Intakes in the lower Red Deer (node 11) decrease sharply from simulation 3, as irrigation expansion here is now negligible. The same comments apply to water consumption. The net result is that the 1987 level of irrigation development, combined with higher return flows from the expanded Sheerness development, virtually eliminates summer water deficits in the Berry subbasin.

The imposition of minimum flow requirements for environmental and recreational purposes has a noticeable impact on the allocation of water resources in the basin. At Red Deer, Drumheller and Bindloss (nodes 7, 8 and 11), outflow deficits occur 10, 27 and 22% of the time respectively. The frequency of these deficits at Red Deer would probably be acceptible, particularly since some improvements , both here and downstream, could be achieved by modest adjustments to the assumed operations policy of the Dickson Dam. The frequency of deficits at Drumheller and Bindloss would probably prove unacceptible . However, these deficits are due to the levels of minimumun specified flows, and not to energy project impacts. The latter require only 10% of these flows. The minimum flow requirements exceed water availability on their own during low flow years. In environmental and recreational terms, the Ardley power station, by requiring transfer of flows to Buffalo Lake, will enhance recreation and the environment in that subbasin while reducing flows in the Red Deer River main stem.

5.8 Concluding Remarks

The analysis presented here was intended for demonstration purposes to illustrate the potential advantages of integrating water use forecasting with water supply considerations. The usefulness of such an approach is clear in that in this example the forecasts have been made functional in terms of water management decision-making. This stands in contrast to the projections which constitute the principal results of this research paper, and which require considerable further interpretation vis-a-vis water supply conditions.

The particular results for the particular basin examined are indicative rather than definitive, given that there is no consideration of the many alternative levels of development and other options such as diversions, increased storage or groundwater exploitation. As a demonstration of model capabilities and potential it has served to highlight some of the positive characteristics of the simulation model at its present stage of development. Any "conclusions" which are read into the results relate to this demonstration as an experiment in methodology, not as exhaustively researched implications for development of the Red Deer basin, which, of course, is primarily a provicial matter.

In the research context, it is necessary to recognize the current limitations of the model. The first limitation is the inability to simulate efficiently the effects of new storage reservoirs or of alternative reservoir operating policies. A second limitation of the model is the absence of a routine for

estimation of groundwater use and availability. Groundwater withdrawals are substantial in some areas, and there are some indications of significant interaction between surface and groundwater sources. Some conceptual work has been done on groundwater methodology, but it remains to develop this into an adequate component of the model. This may, however, prove to be an extremely difficult task. Thirdly, more work is required in the municipal and industrial sectors to move away from sole reliance on the coefficients approach to projecting future water uses.

Another limitation of importance relates to the model's treatment of use priority. When a deficit is identified, there is no priority assigned to one sector over the other. In many cases, this approach will not be appropriate. For example, minimum flow requirements at international and interprovincial boundaries are usually given first priority to satisfy water apportionment agreements. An enhancement of the model in this regard, given its intended national perspective, is seen as important.

Several other items of work which would improve the model capabilities and accuracy have also been identified . The database in the model is now complete only for the South Saskatchewan basin. Currently, the database is being expanded to cover the entire Saskatchewan-Nelson basin, thus allowing for future analyses of almost any river basin in the southern half of the Canadian prairie region. Also, some of the techniques developed in the main part of this paper (e.g. the impact of conservation options, the implications of technological change)

could readily be incorpoated into the simulation modelling context.

In conclusion, it is reasonably clear that water use studies in the future will derive their primary usefullness when used in conjunction with physical resource considerations. The model presented here is quite powerful for this integrative purpose. Further development is required in some essential areas. As development planning continues across the country, future applications of the model should serve to identify potential water supply constraints and feasible alternative development scenarios.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

The principal conclusions of the study are drawn in this chapter. These conclusions relate to the quantitative findings of the research, conclusions about the sumulation modelling approach and a brief recapitulation of research limitations. Recommendations for further work will then be put forward.

6.1 Conclusions

6.1.1. National and Regional Water Use Forecasts

Forecasts of water use have been produced for Canada, its five major regions and 47 principal drainage areas, using a structural econometric approach. Five scenarios, denoting a wide range of future conditions have been analyzed with respect to their impacts of water use. The major variables included economic conditions, changes in production technology and changes on water use pactices. Table 6.1 presents the major forecasted results for Canada in terms of the reference case, with the other four scenarios denoted as deviations from the reference case.

Thermal electrric power generation accounted for the largest proportion of water intake throughout the forecasting period. There is a marked correlation between regional industrial structure and the magnitude of regional water use. Thus, Ontario, with the highest proportion of thermal power production, also dominated the water intake volumes. Similarly, the Prairie regions, with its large areas of irrigated agriculture, was dominant with respect to water consumption. Table 6.2 shows, for

Table 6.1 SUMMARY OF PRINCIPAL RESULTS

Region		Reference Case (MCM)		% Deviation from Reference Case by Scenario in 2011*			
		1981	2011	2	3	4	5
B.C.	Intake	3789	7085	-47	15	-23	14
	Consumption	487	893	-48	11	-23	17
Prairie	Intake	5363	11172	-40	24	-21	15
	Consumption	2339	4410	-49	7	-23	20
Ontario	Intake	21230	42861	-32	25	-21	13
	Consumption	589	1093	-43	13	-23	18
Quebec	Intake	4252	7629	-43	11	-21	17
	Consumption	435	690	-45	13	-18	17
Atlantic	Intake	2884	5584	-33	21	-18	6
	Consumption	139	244	-38	15	-17	8
CANADA	Intake	37518	74331	-36	22	-21	13
	Consumption	3906	7363	-47	10	-22	18

*Scenario 2 = conservation policy scenario;
Scenario 3 = technological change scenario;
Scenario 4 = low growth scenario;
Scenario 5 = high growth scenario.

TABLE 6.2 DOMINANT WATERSHEDS IN EACH REGION, 1981
(VOLUME IN MCM)

Region	Intake	Consumption
B.C.	Pacific Coast (2126) Fraser (952)	Fraser (219) Okanagan (146)
Prairie	N. Saskatchewan (1388) Bow (813)	Bow (483) Oldman (450)
Ontario	Lake Ontario (6946) Lake Huron (5300)	Lake Ontario (231) Lake St.Clair-Erie (218)
Quebec	St. Lawrence (3257) North Shore-Gaspe (435)	St. Lawrence (343) Ottawa (41)
Atlantic	Nova Scotia (1260) St.John-St.Croix (882)	St.John-St.Croix (54) Nova Scotio (35)

each region, the two dominant watersheds with respect to water intake and consumption.

Scenario 2 examined the effects of a conservationist management policy with regard to water use. The vehicle for accomplishing this examination was a set of water use coefficients modified from 1981 levels by an assumed set of water price elasticities, augmented with an extra allowance for non-price related measures. It was clear that these modified coefficients had a pronounced effect on water use, reducing both intake and consumption to below the results obtained using low economic growth forecasts.

Scenario 3, which examined the effects of trends in production technology indicated a trend towards increasing water use, over and above the effect of medium economic growth. The results showed that technological change acting by itself would bring forecasted water near to or above that obtained using the high growth rate set. This result was somewhat unexpected, being at variance with the results of other research. This matter has to be subjected to further investigations in the future.

Based upon all of the research taken together, the following Table 6.3 represents the ranges of water use which can be expected in the future.

TABLE 6.3 EXPECTED RANGES OF WATER USE, CANADA AND REGIONS 1981-2011

(MCM)

Region		Intake		Consumption	
		Low*	High**	Low*	High**
B.C.	1981	3789	3789	487	487
	1991	3950	5043	512	645
	2001	3989	6623	508	850
	2011	3726	8057	464	1046
Prairie	1981	5363	5363	2256	2256
	1991	6167	7569	2494	3172
	2001	6580	10158	2485	4227
	2011	6687	12895	2262	5318
Ontario	1981	21230	21230	589	589
	1991	23987	28355	711	776
	2001	26925	38146	649	1031
	2011	29235	48258	625	1291
Quebec	1981	4252	4252	435	435
	1991	4523	5514	428	525
	2001	4567	7184	417	661
	2011	4327	8901	380	804
Atlantic	1981	2884	2884	139	139
	1991	3222	3795	150	179
	2001	3529	4902	153	223
	2011	3764	5929	151	263
Canada	1981	37518	37518	3906	3906
	1991	41848	50275	4292	5298
	2001	45589	67011	4212	6990
	2011	47738	84039	3882	9025

*Scenario 2

**Scenario 5. Scenario 3 was not chosen here because of the doubt cast by the contradictory research findings.

6.1.2. Simulation Modelling of Water Use

An alternative approach using simulaution modelling at the river basin level was outlined, and found to be advantageous in a number of ways. First, it eliminates many of the problems and limitations associated with the regional input-output model,such as the lack of supply considerations and the structural model's inability to provide detail at the river basin level. In this manner, assessments can be made of future supply:demand imbalances and their severities assessed. Second, the model can be applied for the analysis of the water resources impacts of any conceivable future development scenario. Third, the temporal variations in irrigation water requirements are represented in the model; and by using historical surface water supply data, future water supply:use conditions are evaluated on a long term basis. Fourth, there are no restrictions in the model regarding the spatial detail of water use:supply comparison; thus it can be applied for the analysis of local problems or for overall evaluations of the water resources of a major river basin or a region. Fifth, the model provides an excellent tool to test the impacts of variables such as climatic changes, water pricing and other demand management alternatives, technological changes, etc. on future use:supply conditions.

6.1.3 Limitations of the Study

In Chapter 4 a number of limitations were suggested to this study, which are summarized here. First, the model used was unable to examine subregional areas, with the result that much local detail is lost. It is at the local level that problems such

as water demand:supply imbalances are felt most directly. Second, there is no consideration of water supply in this project, with the result that water imbalance problems, current or potential, have not been dealt with. Third, due to the structure of the model used, each of the thirty sectors received equal attention, when, in fact, greater concentration on the larger water-using industries (e.g. agriculture) would have been warrented in some areas. Fourth, the model used is linear in nature, treating each region essentially in the same manner. This characteristic is a limitation since it fails to reflect real-world conditions. Lastly, the model was limited in the number of variables which could be considered.

With regard to the simulation model, at the present stage of development, the following limitations have been identified. First, it can only identify potentially water-short areas, and quantify the shortages. All water use sectors are given the same priority. The model does not have a mechanism for the analysis of conflict situations, reallocation of the water resources based on use priorities, etc. Second, the effects of new storage reservoirs cannot be simulated explicitly. Third, there is an over-reliance on the coefficients approach to projecting municipal and industrial water uses. Fourth, the current database in the model is limited to a partial coverage of the Prairie Region. Fifth, the model is limited to water quantity aspects. Finally, water supplies from groundwater sources and their interconnection with surface water sources are not built into the model. Current research suggests

considerable interplay between surface is groundwater in influencing an area's water supply.

6.2 Recommendations

Based upon the limitations to the research carried out in this paper, a number of directions for improvement and future work can be suggested.

6.2.1. Integration of Water Use and Water Supply Studies

That some areas of Canada can be termed areas where water is in short supply, there can be little doubt. While this particular research report has not come to terms with this issue, the examination of water shortage situations is a primary goal of water use and demand forecasting. From a preliminary examination of water availability figures completed for the Inquiry, it seems that a number of areas, particularly in Western Canada, are ones of current or potential water shortage (Hess, 1985).

The real value of demand forecasting will be derived when demand and supply are integrated at levels effective in identifying and quantifying water imbalance problems. A practical methodology for achieving such an integration was suggested in Chapter 5, and it is recommended that such a methodology be refined and applied to major basins in Canada, beginning with those basins where water supply:demand problems are current or threatening or and later to the other major basins of the country Further. the development and improvement of the river basin simulation model should be given top priority in regard to water use and demand

studies, and should be funded at a level higher than currently available.

6.2.2. Continued Development of Regional Water Use Modelling

The main research carried out here was concentrated on projecting water use in the major regions of Canada. A number of assessment, such as watching briefs on overall national water use, studies of future consumptive water use, and policy evaluations will continue to be based on such projections and modelling activities. It is recommended that development and application work on these aggregate models be continued.

6.2.3. Further Investigation of Conservation Measures

Scenario 2 demonstrated that significant reductions relative to other growth paths may be achieveable through improved water pricing practices and other conservation measures. The analysis here, however, was quite hypothetical, and relied upon a number of assumptions and secondary data sources. It is recommended that further research be carried out on this subject in order to investigate fully the impacts of conservation measures, not only on future water use but also upon the requirements for new water supply development initiatives.

6.2.4 Examination of Technological Change Impacts

The subject of technological change impacts on water use were examined in Scenario 3, with the indication that production technology was tending to lead to proportionately increased water use relative to current technologies. Since this finding is a variance with other research on the subject, as outlined in Chapter 4, it is recommended that further work be carried out in

order to bring the technological change fully into the calculus of water demand forecasting.

6.2.5. Water Use Data

The undertaking of this project was due in part to the availability of reliable Canadian data on various aspects of water use. These data have been collected regularly over the past 10 years. It is recommended that such data collection efforts, which have been relatively inexpensive in resource terms, be continued, both to verify the accuracy of the forecasts and to provide data for improved forecasting efforts. Such data collection efforts should ensure that data are collated on a river basin basis in order to feed data to the simulation model being developed, as well as on the basis of political regions

6.2.6 Nonwithdrawal Water Uses

This report has considered only the major withdrawal uses of water. However, the nonwithdrawal water uses (e.g. recreation, wildlife, hydroelectric power, etc.), are a dimension of water use which have generally been underplayed, not only here but also in other studies. It is recommended that research be carried out to identify the most efficient method of incorporating nonwithdrawal water use considerations into investigations of future water demand. This work should be carried out in conjunction with the investigations recommended in Section 6.2.1.

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